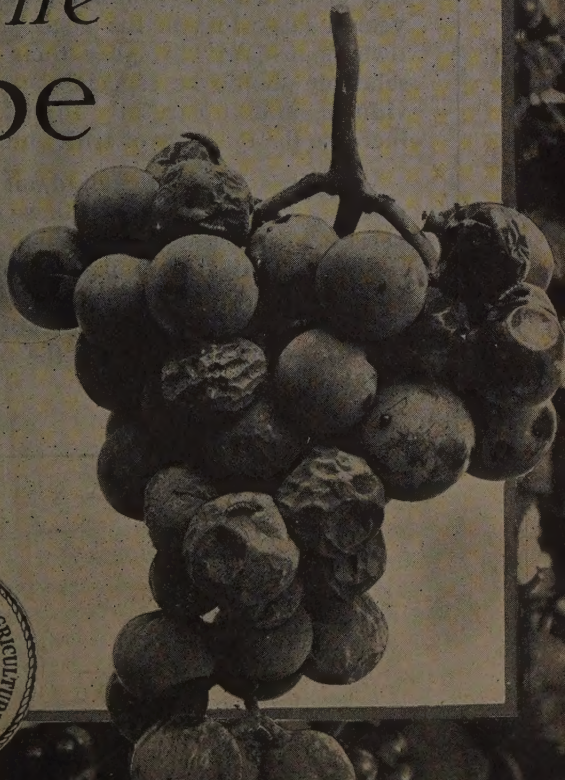
Farmers' Bulletin 1220
United States Department of Agriculture

Insect and Fungous Enemies of the Grape



THE present paper treats of important insect and fungous enemies of the grape in the United States, and gives for each the methods of control at present known to be most effective. There is also given at the close of the bulletin a schedule of applications of combined insecticides and fungicides which, if carried out according to directions, will insure a high degree of protection from the various insect and fungous troubles of the grape. Commercial vineyardists, for the most part, follow some schedule of applications, though in many instances sufficient attention is not given to thoroughness or timeliness in treatments.

In the case of grapes grown principally for home use, or on a small commercial scale, there is each year a large loss in the aggregate from failure of owners properly to spray their vines. The spray schedule should be especially useful to these individuals, and if carefully followed will materially increase the quantity of fruit obtained.

Vineyards, however, should not be sprayed so near ripening time of fruit that there will be left on the berries at harvest a noticeable amount of spray residue. Thorough applications early in the season as indicated in the schedule of treatment (p. 74) will obviate the necessity of later treatments with consequent discoloration of the fruit with the spray mixture.

INSECT AND FUNGOUS ENEMIES OF THE GRAPE.

A. L. QUAINTANCE, *Entomologist in Charge, Fruit Insect Investigations, Bureau of Entomology,* and C. L. SHEAR, *Pathologist, Fruit-Disease Investigations, Bureau of Plant Industry.*

CONTENTS

CORRECTION SLIP FOR FARMERS' BULLETIN 1220.

Page 5: This illustration shows the feeding marks of the grape rootworm beetle and should be figure 43.

Page 6: The cuts of figures 3 and 4 should be transposed.

Page 41: This illustration shows cocoons of the grape-berry moth and should be figure 2.

The grape leaf skeletonizer 28
Climbing cutworms 29
Fly gall-makers 30
Hawk moths 33
Insects affecting the canes 35
The grape scale 35
The grape mealybug 36
The grape cane-borer 38
The grape cane gall-maker 39
The grape cane-girdler 39
Insects affecting the roots 40
The grape rootworm 41
The California grape rootworm 43
The grapevine root-borer 43
The grape phylloxera 45
Neutral copper acetate 70
Sprayers 70
Bucket pumps 70
Small compressed-air pumps 71
Barrel pumps 71
Spraying outfits for large operations 72
Gasoline power sprayers 72
Dusting apparatus 73
Spraying accessories 74
Spray nozzles 74
Strainers 74
Grape-spraying schedule 74

INSECT ENEMIES.

THE INSECT ENEMIES of the grape in the United States important at the present time are native American species, feeding originally, even as now, on various wild species of grapes and related plants. When vineyards were planted and the grape-growing industry extended, many species attacked the cultivated varieties and some few have become exceedingly troublesome pests. Perhaps no horticultural crop so well illustrates the serious loss which may result from native species of insects attacking cultivated varieties of their natural wild food plants as does the grape.

Of the large list of species of insects known to feed on the grape in the United States those treated herein include the ones of prin-

cipal importance. Several of these species in certain sections rank as first-class pests, such as the grape rootworm, grape-berry moth, grape curculio, grape leafhopper, grape leaf-folder, grapevine flea-beetle, rose-chafer, grape phylloxera, and the like. Some of the species treated are ordinarily not important except during occasional seasons, or more or less locally, but are nevertheless the subject of considerable inquiry each year.

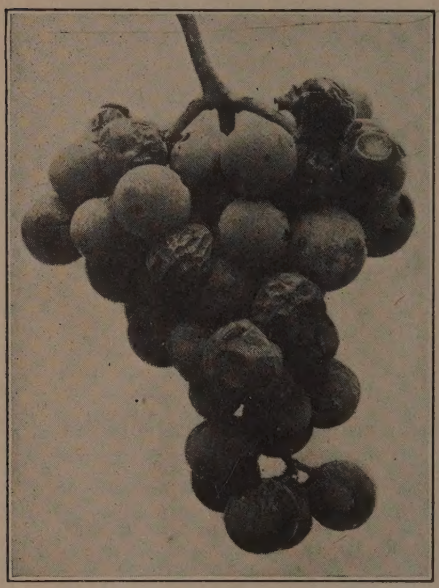


FIG. 1.—Grapes injured by grape-berry moth larvæ.

Grape insects are not less amenable to treatment than insect pests of other fruit crops, and the vineyardist may confidently expect to keep them under control by the application of the remedies herein recommended. As the reader will learn in the following pages, the principal insect and fungous enemies of the grape may be controlled with material reduction of cost by timely and thorough applications of a spray in which are included one or more insecticides and a fungicide. As in the control of most other insect pests, cultural methods are of very great importance. Vines kept in a vigorous and healthy condition by cultivation and fertilization are better able to withstand insect attack than those growing under conditions of neglect.

INSECTS ATTACKING THE FRUIT AND BLOSSOMS.

THE GRAPE-BERRY MOTH.[1]

The larva of the grape-berry moth infests the berry or fruit of the grape. The first generation attacks and webs together the grape clusters, even before the blossoms open, or soon after the grapes are set. Later appearing larvæ bore into the green or ripening fruit, often producing purplish spots, much resembling in appearance the injury due to the black-rot fungus. Within the fruit the larva feeds on the pulp and seeds, passing from one grape to another, and several discolored and shriveled berries will often be found more or less webbed together with particles of larval excrement and sticky with exuding grape juice (fig. 1).

[1] *Polychrosis viteana* Clemens.

The insect occurs from Canada south to the Gulf and westward to the Great Plains States. It has been reported in injurious numbers in New York, Pennsylvania, Ohio, Illinois, Missouri, Maryland, Texas, Virginia, and Canada. It is rather chronically troublesome in northern Ohio vineyards, as a result probably of a combination of causes. The extensive cultivation of the late maturing variety, Catawba, favors the development of the second brood of larvæ, which are mostly able to mature and find winter quarters in and around the vineyard before the crop is harvested. The practice in this region of plowing the earth to the vines in late fall and plowing it away again in the spring is a procedure that best insures the successful hibernation of the insect by covering up the pupæ in the leaves under the trellises; also the system principally employed for training the vines—namely, the fan system—is less favorable to the thorough application of sprays than are systems of training mostly in vogue in the Erie-Chautauqua grape belt. In the latter region the occurrence of this insect in seriously injurious numbers is more sporadic and local; nevertheless the amount of injury occasioned by it is on the average quite important. It appears that in the commercial grape-growing districts of Michigan, as in the neighborhood of Benton Harbor, Paw Paw, and Lawton, the grape-berry moth has not thus far proved to be of importance. Neither is the insect known to occur in the vineyard areas of California.

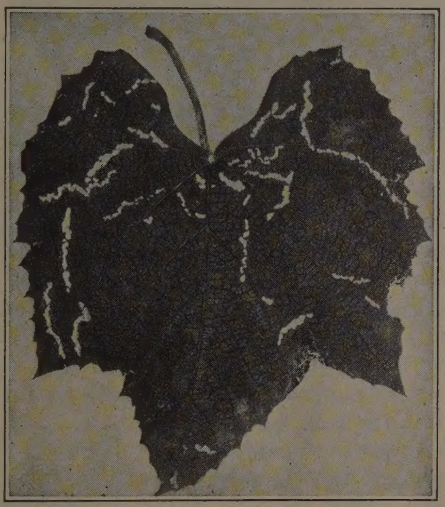


FIG. 2.—Cocoons of grape-berry moth as found on fallen grape leaf.

LIFE HISTORY AND HABITS.

The insect passes the winter in the pupal condition in fallen grape leaves in the vineyard (fig. 2). Most of the insects occur in the damp and decayed leaves along the rows of vines rather than in the drier leaves, which are blown readily here and there by the wind. Moths (fig. 3) from hibernating pupæ begin to appear in the spring when the shoots of the grape are well out, and continue to emerge for some weeks. The earlier appearing moths deposit their eggs on the blos-

som clusters, while those emerging after the blossoms are shed oviposit mostly on the clusters of young grapes. The minute scale-like eggs of the first brood are difficult to find, as they are relatively scarce, but they may be readily detected during the late summer and fall as glistening white spots on the surface of the green or ripening berries. Larvæ of the first brood feed upon the blossoms, webbing them together, and by their injury producing a more or less irregular bunch of grapes, or the clusters may be almost entirely destroyed. This brood, however, is usually small, because of the heavy mortality of the insects during the winter.

FIG. 3.—The adult grape-berry moth. Enlarged.

After feeding about three weeks the larvæ attain full growth (fig. 4), go to the leaves and cut loose a small portion which is folded over against the leaf surface (fig. 2), and under this flap a cocoon is made where the pupa stage is passed (fig. 5). In the northern grape-growing areas most of the first or spring brood of pupæ develop to moths the same season, but a few may remain in this stage until the following spring. In the Erie-Chautauqua and northern Ohio grape areas moths of the second, or summer brood, begin to appear about the middle of July, emergence continuing well into the fall, with a heavy emergence during normal seasons the latter part of July. The summer brood of larvæ with the later appearing individuals greatly exceed in numbers those of the spring brood and attack the berries almost exclusively, feeding on the pulp and seeds, passing from one grape to another in the course of their feeding (fig. 6). When full grown the larvæ go to the leaves and construct cocoons under a leaf flap, where the pupa stage is entered and the winter passed. Usually the older leaves are chosen by the larvæ, and as a result the pupæ are most abundant on the earlier dropped leaves under the trellises. These leaves later become more or less covered with other leaves and trash, which act as a protective covering, much enhancing the chances that the pupæ will go through the winter safely.

FIG. 4.—Larva of the grape-berry moth. Enlarged.

CONTROL.

The grape-berry moth can be effectively controlled by thorough, timely sprayings of the vines with arsenate of lead. Two applications of the poison are necessary; the first, three to four days after the blossoms have fallen; the second, when the little grapes begin to touch in the cluster, or about three to four weeks after the first treatment. The spray should be directed against the blossoms or fruit clusters, as these should be thoroughly coated to insure destruction of the larvæ. The poison is used at the rate of 1½ pounds of the powder or 3 pounds of the paste to each 50 gallons of spray. Where smaller quantities are desired, the poison is used at the rate of 2.4 ounces of the powder, or 4.8 ounces of the paste, to each 5 gallons of liquid.

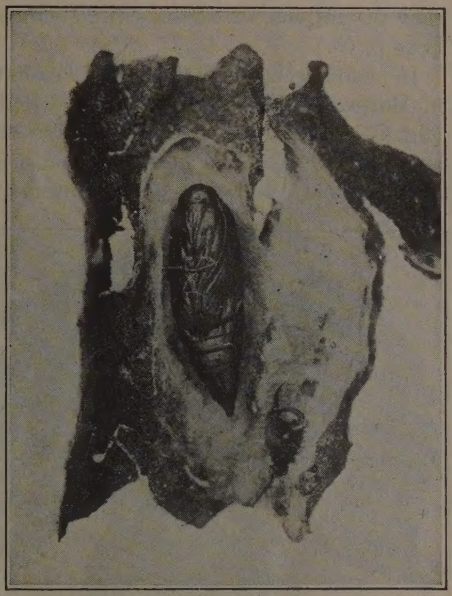


FIG. 5.—Cocoon and pupa of grape-berry moth. Enlarged.

It is desirable to apply the poison in the Bordeaux mixture (pp. 68–70), necessary for the control of fungous diseases. If the arsenical is used in water, the milk of lime from 2 pounds of stone lime per 50 gallons should be added. One pound of rosin fish-oil soap to each 50 gallons of spray adds much to its adhesive qualities. Rosin laundry soap may be used if the former kind is not available. Little if any residue will persist on the fruit at harvest time from these two early treatments, and if these are thoroughly made they will, in the experience of the Bureau of Entomology, give

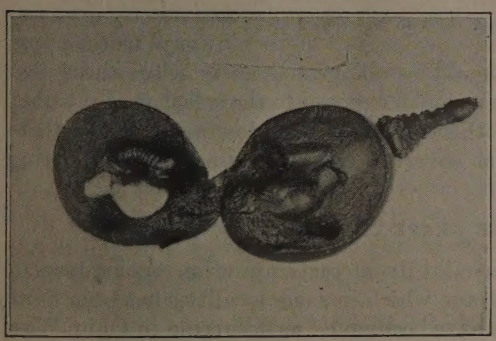


FIG. 6.—Grape berry infested by larva of grape-berry moth. Enlarged.

as good results as if additional applications were made with consequent danger of spray residue on the fruit at harvest time. On vines where the grape leafhopper is troublesome, there should be added to the second spray 40 per cent nicotine sulphate at the rate of ¼ pint to each 50 gallons, or about ½ fluid ounce to each 5 gallons of spray. (See p. 65.)

In commercial vineyards the arsenate of lead is generally used in Bordeaux mixture and the so-called trailer method of spraying (fig. 76) is recommended. This plan merely consists in the employment of two leads of hose with short spray rods to be handled by men on the ground, thus permitting much more thorough application of the liquid than by a fixed nozzle system. On pages 74–75 a schedule for the season of spraying grapes is given, which under ordinary conditions will afford maximum protection from important grape insects and diseases.

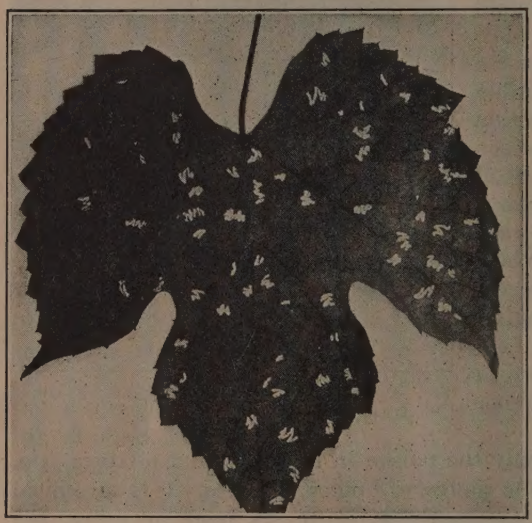


FIG. 7.—Feeding marks of grape curculio on grape leaf.

In the home vineyard it will often be practicable to rake up and burn the earlier falling leaves, thus destroying many grape-berry moth pupæ. Commercial vineyards should be so treated as to leave the fallen foliage under the trellises as much exposed to the weather as possible. From the grape-berry moth standpoint, fall plowing of the earth to the vines is undesirable as covering and protecting the hibernating pupæ under the trellises.

THE GRAPE CURCULIO.[2]

The grape curculio periodically attracts attention on account of the injury it does to the grape which in some localities has been quite severe. Important losses have been noted as occurring in Ohio, West Virginia, Illinois, Kentucky, and Arkansas. It occurs from New England south to Florida, and westward to Minnesota, Missouri, and Arkansas.

[2] *Craponius inaequalis* Say.

LIFE HISTORY.

The adult beetles appear to feed exclusively upon grape, wild and cultivated. They appear in vineyards in the spring about the time the Concord grape is in blossom, and spend 10 days or two weeks feeding on the foliage before beginning egg laying. The feeding marks are characteristic and occur on the upper surface of the leaves as short, somewhat curved lines, usually in groups, as shown in figure 7. The presence of this insect in vineyards can be detected best by these feeding marks on the leaves.

Eggs are placed singly in little cavities cut into the fruit (fig. 8), and the resulting larvæ bore into the flesh, feeding also on the seeds (fig. 9). After about three weeks the grubs have attained full growth and go to the ground, where they construct little earthen cocoons from which the parent beetles emerge in the course of three or four weeks. After emergence the new brood of beetles feed on grape foliage until the approach of cold weather, when they seek shelter under trash of various kinds and hibernate until the following spring.

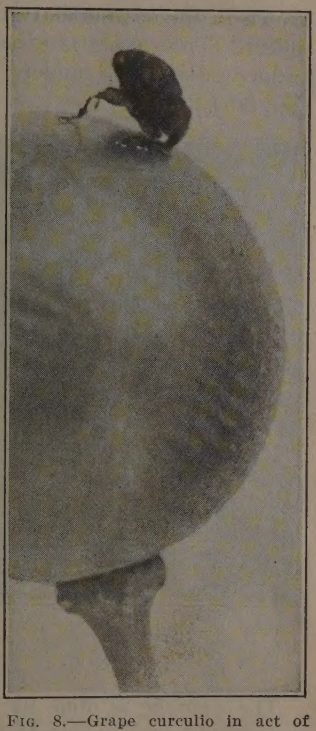


FIG. 8.—Grape curculio in act of excavating egg cavity on grape berry. Considerably enlarged.

CONTROL.

Because this insect feeds on the upper surface of grape leaves for some time before egg laying, it can be successfully controlled by arsenical sprays, such as arsenate of lead. Several times practically complete freedom from this pest has been obtained by the use of this poison at the rate of 1½ pounds of the powder or 3 pounds of the paste to each 50 gallons of water or Bordeaux mixture. The first application is given just after the blossoms fall and the second three or four weeks later. Vineyards sprayed according to the grape-spraying schedule (p. 74) will be practically free from attack by the grape curculio.

THE GRAPE BLOSSOM MIDGE.[3]

The grape blossom midge is a rather recent addition to the list of American grape pests, having been first recognized in 1904 in the

[3] *Contarinia johnsoni* Slingerland.

vicinity of Westfield, N. Y. It has since been found rather generally over the Erie-Chautauqua grape belt, and in 1919 was present in injurious numbers in certain vineyards in the vicinity of Sandusky, Ohio. It is likely to spread gradually over the country except as limited by climatic and other factors. Early varieties of grapes, such as Moore Early and Worden, are most subject to attack, whereas the Concord, Niagara, and other later blooming sorts principally grown in the commercial grape districts in the East, largely escape injury. This insect is a near relative of the gall-making gnats or midges discussed under the caption of "Fly gall-makers" (pp. 30–33).

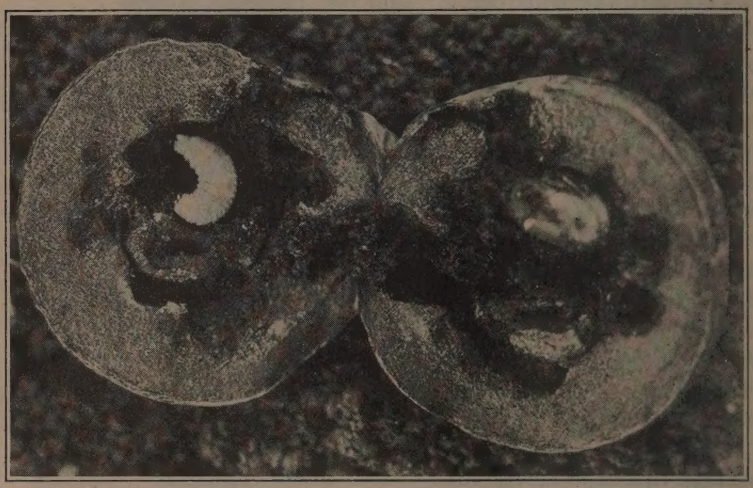


FIG. 9.—Grape berry infested by larva of grape curculio. Considerably enlarged.

LIFE HISTORY.

The damage is done by the larvæ or maggots, which infest the unopened buds, causing these to shed, and thus thinning the bunches of grapes. Infestation is indicated by the enlarged size of the buds which often become two or three times larger than uninfested adjacent buds (fig. 10). The number of larvæ in a given bud will vary greatly from a few to as many as 70, and the destruction of buds may reach as high as 60 per cent.

In the Erie-Chautauqua region, the adult fly or midge comes from the ground the latter part of May, at which time the blossom buds of early varieties are more or less spread at the apex. By means of a long flexible ovipositor, the female places its eggs within the buds, and in a few days these hatch into whitish maggots. After about two weeks of feeding the maggots are grown, at which time they are mostly of an orange or reddish color. The buds are then deserted,

the larvæ burrowing beneath the soil where they construct cocoons in which they remain until the following spring. Pupation begins in late April, the adults emerging in time to deposit eggs in the earlier blooming varieties of grapes.

One very important chalcid parasite[4] has been reared from the grubs, as well as from those of the Catalpa midge, and is probably of considerable importance in keeping the insect in check. Unfortunately no very effective control measures for this insect are known. Experiments made by the Geneva, N. Y., Agricultural Experiment Station indicate that a nicotine extract sprayed over the plants will aid in reducing the number of eggs deposited.

FIG. 10.—Grape blossom cluster infested by maggots of grape blossom midge. Much enlarged.

THE GREEN JUNE BEETLE.[5]

The green June beetle is frequently complained of locally as destroying bunches of ripened or nearly ripened grapes. It attacks also other fruits, as peaches, plums, pears, figs, etc., and corn when in a milky condition. The insect occurs throughout the Southern States and along the Atlantic coast to about the region of southern New York. In the Southwest it is replaced by a related form with similar life history. The green June beetle, or fig eater, as it is called in the South, is dull green in color, more or less brownish on the sides. The females are somewhat larger than the males, averaging about an inch in length. The beetles appear when early sorts of grapes, peaches, etc., are ripening, often in large numbers, as 15 to 20 beetles to a single bunch of grapes, which may be quickly destroyed, only the empty hulls remaining (fig. 11). When disturbed the beetles fly away with a buzzing noise, some falling downward, others darting away above the vines.

The parent beetle lays her eggs in the soil and the young grubs burrow freely through the earth, feeding on decaying vegetable matter. There is only one generation each year, the winter being passed in the immature larva stage, growth being completed the following spring. The prevalence of this pest is thought to be connected with the occurrence adjacent to vineyards of decaying vegetable matter, as composts and old stable manure, or land which has

[4] *Zatropis catalpae* Crawford. [5] *Cotinis nitida* L.

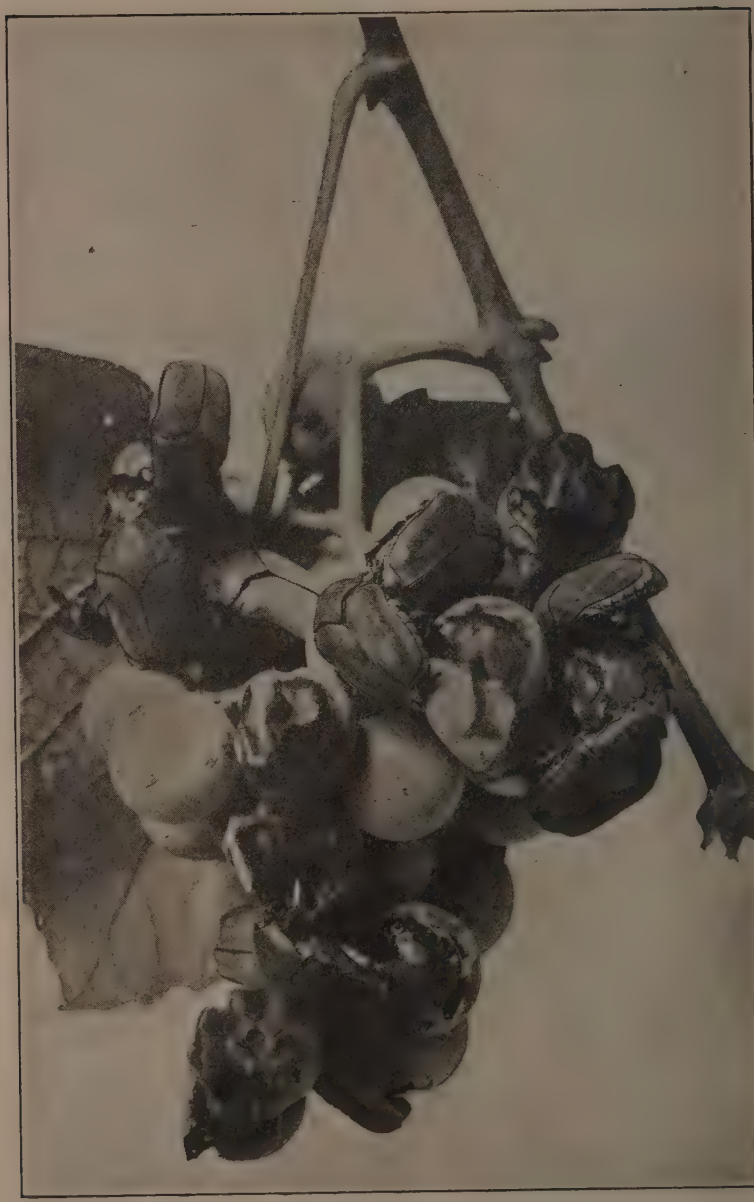


FIG. 11.—Green June beetles and their injury to grapes.

been heavily manured. An excessive quantity of humus in the soil is thought greatly to favor the insect.

CONTROL.

The use of poison sprays on ripening fruit is impracticable and other methods must be employed. Bagging the fruit when it begins to color and allowing the bags to remain in position on the bunches until gathered has been employed with much success and is worth while in localities where damage is to be expected more or less each year. Considerable benefit follows systematic hand picking of beetles or knocking them from the vines into a pail of water bearing a film of kerosene. This work is best done in the morning, when the insects are more sluggish than during the heat of the day. Whenever practicable, piles of compost and unusual quantities of humus on the soil should not be allowed in the neighborhood of vineyards.

BEES.

Frequent complaint is received from vineyardists of the destruction of the fruit by bees, and numerous actions in court have been taken against owners of colonies of bees to recover for loss of fruit supposed to have been destroyed by these insects.

Experiments by entomologists and others have proved conclusively that honeybees can not break the skin of sound grapes with their mouthparts. Bees confined with bunches of sound grapes will die of starvation. Where the skin of the grape has been broken, however, as by other insects or fungous diseases, bees attack the berries at the injured places and may quickly reduce the fruit to a worthless condition. Injury by bees is best avoided by protection of the fruit from insects and diseases which interfere with its soundness. In the absence of spraying, fruit in danger of attack by bees can be protected by bagging the bunches after the fruit is well set, or shortly before ripening begins.

INSECTS INJURING THE FOLIAGE AND BUDS.

THE GRAPE LEAFHOPPER.[6]

Throughout the United States and Canada wherever the grape is grown, the grape leafhopper will almost invariably be found in greater or less numbers infesting the lower surface of the leaf, where it feeds and breeds, increasing in numbers as the season progresses until by late summer and fall the vines are often literally swarming with it. Over its extended range the insect every year may be quite destructive in one or more localities, or it is likely to become so at any time. The grape leafhopper is an insidious pest usually not

[6] *Typhlocyba comes* Say.

noticed by the vineyardist until late summer and fall when the yellow and brown-blotched leaves fall prematurely, by which time the injury has been done. The insects in feeding extract large quantities of liquid food, sucking it from the leaf by means of piercing mouthparts. Often feeding constitutes a heavy drain on the vitality of the plant. The injury to and loss of leaves prevent the proper assimilation of food by the vines; and the fruit may be materially reduced in size and may lack much in flavor and sugar content (fig. 12). Although the annual loss of grape growers from this species is enough to place it among the first-class pests of the vine, it is only comparatively recently that systematic efforts have been made to control it in some of the important grape-growing regions. There are numerous records of its injury in the Erie-Chautauqua grape region during the past two decades and growers in that region probably more generally treat vineyards for the control of this pest than elsewhere. In California it is stated to be, next to the phylloxera, the most important of all insect pests of the vine.

FIG. 12.—Defoliated condition of grapevine by late summer from attack of grape leafhopper.

LIFE HISTORY AND HABITS.

The grape leafhopper is quite small, measuring not over one-eighth of an inch in length, and is very agile, moving with equal facility in all directions. It flies out from the vines often in swarms on slight disturbance. In general appearance it is light yellow, with deeper yellow or red markings, the exact pattern and color varying much among the different individuals and according to season (fig. 13). There are numerous varieties of the insect as based on these variations. The winter is passed by the adults in hibernation in trash in and near vineyards, in the edges of neighboring woods, in grass along gullies, in ditches, etc. Early in the spring the insects come from winter quarters and attack almost any succulent vegetation at hand. By the time the foliage of the grape is well out, they are

out in numbers and infest the vineyards. The adult hoppers of the hibernating generation feed and breed on the lower or early appearing grape leaves, gradually disappearing as the season progresses, but not before some of their progeny have reached the adult condition. Eggs are placed just beneath the epidermis in the lower leaf surface, usually singly, but also in groups. When just hatched the young hopper or nymph is very small, whitish in color, with red eyes, later becoming striped with yellow. The nymphs (fig. 13, *c*) feed in the same manner as the parents, sucking juice from the leaves, at first from the lower surface of the older leaves where they were born

FIG. 13.—Grape leafhopper: *a*, Mottled appearance of injured grape foliage; *b*, the adult hopper; *c*, nearly full-grown nymph.

but later spreading more or less generally over the plant. They are very agile, running in all directions, but do not leap or hop. In the course of their growth they molt several times, and the cast skins are usually in evidence in numbers on the lower surface of infested leaves (fig. 14).

In the northern States there is each year one full brood of nymphs and a partial second, the extent of the second varying according to season. Farther south the second generation is doubtless complete, with perhaps a third in some sections. By late summer and fall the insect is often exceedingly abundant, and all stages are to be found

together on the leaves continuously until the approach of cold weather, when the adults seek suitable hibernation quarters as described.

CONTROL.

Extensive tests of sprays by the Bureau of Entomology and others in the East have shown conclusively that the grape leafhopper can be controlled by a single application of a spray of dilute nicotine, such as nicotine sulphate containing 40 per cent nicotine. The nicotine sulphate is used at the rate of approximately one-fourth pint to each 50 gallons of spray, and in general it may be added to the Bordeaux mixture and arsenate of lead spray, employed for the treatment of other grape insects and diseases, as described in the spraying schedule (p. 74). Where the leafhopper is especially troublesome

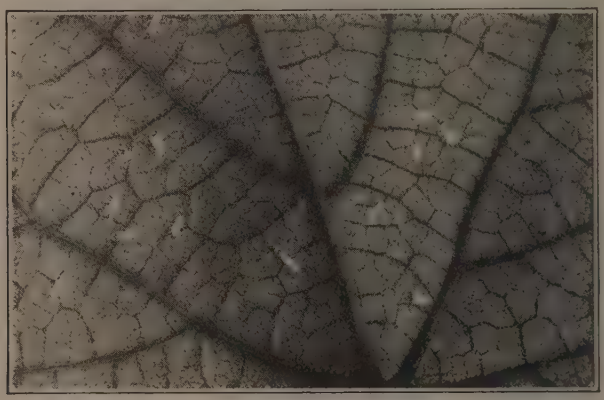


FIG. 14.—Grape leafhopper. Cast skins of nymphs on undersurface of grape leaf.

it should be promptly treated when the nymphs are in the proper stage of growth (see fig. 12, *c*), even if an extra treatment is necessary. It is essential to direct the spray against the nymphs on the lower surface of the leaves, and fairly coarse nozzle disks should be used, as a fine mist spray does not wet the insects sufficiently to kill them. The so-called trailer method (p. 72) of spraying has been found best to secure effective results, though in fairly level vineyards a system of nozzles mounted on swinging booms, developed by the Geneva, N. Y., Agricultural Experiment Station, has been employed with success. When treating only this insect, as may often be the case in California, the nicotine sulphate may be used in water, but there should be added rosin fish-oil soap, at the rate of 1 pound to 50 gallons of water, to improve the spreading and adhesive qualities of the liquid.

It is of the utmost importance that the first treatment be made at a time when the first-hatched nymphs are near the last molt and before they have developed wings. This will insure the destruction of the maximum number of the still younger insects. This time can be determined by examining the hoppers on the lower surface of the leaves. The earliest full-grown nymphs at this time will have the wing pads

FIG. 15.—Showing excellent condition of foliage and fruit as a result of spraying for the grape leafhopper.

reaching nearly or quite one-half the length of the body (fig. 12, *c*). For the Erie-Chautauqua grape belt this will be in ordinary seasons during the second and third weeks of July. One thorough, forceful spraying will so check the insects that further applications will be unnecessary. In fact, later applications have relatively little value, owing to the presence of many adults, which fly from the plants upon the least disturbance.

It is entirely practicable to use the nicotine spray on vines growing around the home, using the nicotine sulphate at the rate of about one-half fluid ounce to each 5 gallons of soapy water. Spraying for the leafhopper when the leaves are yellow and brown, as in late summer and early fall, will not be profitable. In localities where this pest is usually troublesome careful watch should be kept in late spring or early summer of the older lower leaves and the spray applied before the first-brood nymphs attain wings, as above indicated. The injurious effect of the grape leafhopper in causing the shedding of the leaves is shown in figure 12, and the benefits resulting from the control of this pest by the nicotine spray are shown in figure 15. The destruction by burning, in the fall and early spring, of weeds and grasses growing along ditches, fences, and hedgerows, or around vineyards, will be highly advantageous as removing suitable hibernating quarters of the insect.

FIG. 16.—Injury by grape leaf-folder to grape leaf.

THE GRAPE LEAF-FOLDER.[7]

During midsummer and early fall the work of the grape leaf-folder is often in evidence on vines growing around the home, or in vineyards not regularly sprayed with arsenicals. The caterpillar folds the lower surface of the leaf over against the upper surface (fig. 16) and when they are abundant the lighter color of the lower leaf surface readily indicates their presence, even though the observer is some distance from the vines. Within the folded leaf the active slender larva feeds upon the interior (upper) surface of the leaf, eating out the soft tissues, leaving the veins and veinlets fairly well intact. Sometimes the grape blossoms are eaten by the caterpillars, but this is unusual. This injury causes many of the leaves to fall and prevents the proper ripening of the fruit.

The insect is widely distributed over the United States and a few are to be found in vineyards in any locality almost every year. During some seasons or for a series of years it may be quite abundant locally and require treatment.

[7] *Desmia funeralis* Hübner.

The insect winters in the pupa stage in the folded and fallen leaves, the moths appearing shortly after foliage puts out in the spring. Eggs are laid on the leaves and the larvæ soon begin to fold the leaves as described. In California, this insect on vinifera grapes is said to roll the leaves rather than fold them. In about a month after hatching the caterpillars are full grown and are grass green in color and about three-fourths of an inch in length (fig. 17). The pupa (fig. 18) is brown in color, about one-half inch long. This stage lasts for about a week or 10 days, and then the moth appears. In the adult stage the insect is rather striking in appearance (fig. 19), the wings expanding about an inch. The wings are dark brown or nearly black in color, with a narrow white band and with conspicuous white spots, varying according to the sex. There are two broods of larvæ each season and perhaps a third in the South. In the Middle and Northern States it is the second brood which is principally injurious.

FIG. 17.—Grape leaf-folder larva as exposed by opening folded leaf. Enlarged.

FIG. 18.—Pupa of grape leaf-folder. Enlarged.

CONTROL.

In vineyards regularly sprayed with arsenicals for other grape pests the grape leaf-folder will rarely, if ever, cause important injury. In vineyards and on vines much subject to attack, pains should be taken to spray the plants with arsenate of lead when the first signs

of the folded leaves are noticed. An additional application in a week or 10 days is desirable in case the insect has been seriously troublesome during preceding years. In small plantings it will be practicable to destroy the larvæ by crushing them within the folded leaf by hand.

THE ROSE-CHAFER.[8]

About the time of blooming of grape in the spring the rose-chafer may suddenly put in an appearance, often in enormous numbers, the long, spiny-legged, awkward, brown beetles (fig. 20) literally covering the plants, feeding at first on the blossoms, but later attacking the young fruit and foliage, the leaves being eaten bare except the

FIG. 19.—Grape leaf-folder moth. Enlarged.

larger veins (fig. 21). Injury to the young grapes often results in their cracking as they grow, the seeds sometimes protruding. This insect is a very general feeder, attacking practically all fruits, such as the apple, plum, cherry, peach, and many ornamentals like Spiræa, Deutzia, and roses. On this last-mentioned plant it is especially severe when abundant, and hence the common name of rose-chafer. After three or four weeks of feeding the beetles may disappear as quickly as they came.

This pest is widely distributed and occurs from Canada and Maine south to Virginia and Tennessee, and west to Oklahoma and Colorado. Light, sandy soils are favorable breeding grounds for the insect and vineyards in regions of clay soils are usually not seriously troubled by it.

[8] *Macrodactylus subspinosus* Fab.

LIFE HISTORY.

The beetles appear early in June, the date varying according to locality and season. Soon after mating feeding begins and continues for from 3 to 4 weeks. Eggs are deposited singly a few inches below the surface of the soil and hatch in two or three weeks. The young grubs feed on the tender rootlets of grasses and other vegetation and become nearly full grown by fall. With the appearance of cold weather they go deeper in the soil, each larva forming a hibernation cell, where they remain until spring, when they go near the surface and may feed more or less. In April or in early May or later, according to latitude, the grubs change to pupæ, and finally adults, about the time the grapes are in bloom. There is but one generation of the insect each year.

FIG. 20.—The rose-chafer on grape blossom cluster. Enlarged.

CONTROL.

Experiments made by the Bureau of Entomology in the grape belt of the Lake Erie Valley indicate that considerable protection of vineyards from rose-chafer injury may be obtained by timely and thorough use of arsenical sprays, the amount of benefit varying with the abundance of the insects. Since the use of poison sprays at the time of rose-chafer invasion is desirable for the control of other grape pests, such as the grape-berry moth, grape flea-beetle, and root-worms, vineyards in sandy regions and subject to rose-chafer attack should be sprayed regularly for this insect as a part of the routine of vineyard spraying.

Arsenate of lead is principally used at the rate of 2½ to 3 pounds of the powdered form to each 50 gallons of liquid. The poison preferably should be used in Bordeaux mixture, essential for the control of fungous diseases. The first application of spray should be given just before the blossoms open, and if the beetles continue destructive the treatment should be repeated as soon as the blossoms have fallen.

FIG. 21.—Grape foliage severely injured by rose-chafer.

Some vineyardists have reported benefit from addition of glucose or molasses to arsenate of lead as rendering the spray attractive to the beetles. Experiments by the Bureau of Entomology have not shown added protection to vines so treated.

According to experiments by the New Jersey Agricultural Experiment Station, the self-boiled lime-sulphur wash (p. 66) thoroughly sprayed over the vines protects them from further important injury by this insect. The wash has been used with equal success in pre-

venting injury to apply, cherry, and peach. Application should be made upon the first appearance of the beetles in numbers.

The old-fashioned remedy of hand picking is of service in protecting grapes growing around the home. The beetles may also be jarred from the plants onto sheets saturated with kerosene. These methods are tedious and must be practiced daily in the early morning or toward sundown to be effective. Choice plants may be securely protected by covering with netting or other suitable material.

In addition to the use of any of the methods described above, considerable can be done by destroying the insects in their breeding grounds. In the pupa stage they are so extremely sensitive to disturbance that stirring of the soil, as by cultivation, would doubtless be fatal to a great many of them. The plowing should be done to a depth of 3 or more inches, and in the Great Lakes region the time for such treatment will vary from about May 25 to June 10 and earlier in southern and warmer localities. In regions where sandy soils predominate the land in the neighborhood of vineyards should not be devoted to meadows, but planted to crops which require annual plowing and cultivation.

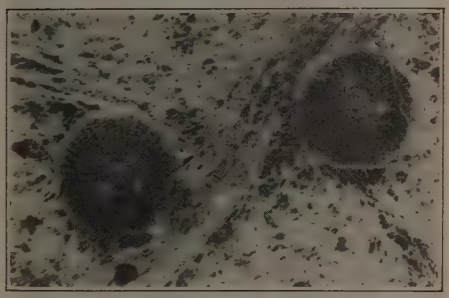


FIG. 22.—Eggs of 8-spotted forester. Greatly enlarged.

EIGHT-SPOTTED FORESTER.[9]

The caterpilllars of the eight-spotted forester moth probably never do injury in commercial vineyards, but are prevalent principally in small unsprayed home plantings. Although the insect is present rather generally over the Atlantic States, its occurrence in injurious numbers is decidedly local. Recently it has been the subject of much complaint in Brooklyn and other points on Long Island, in portions of Connecticut, and elsewhere in that general territory. Injury results from the defoliation of the vines by the caterpillars, and all varieties of grapes are apparently subject to attack. The larvæ feed also on wild grape, barberry, and Virginia creeper, and on this latter plant they are sometimes quite troublesome in parks.

In the Northern States, at least, the insect is single brooded. The moths are out during May and June and deposit their eggs on leaves of the host plant (fig. 22). The eggs hatch in 4 or 5 days, the result-

[9] *Alypia octomaculata* Fab.

ing larvæ feeding voraciously on the foliage, which may be stripped from the plants when the caterpillars are abundant (fig. 23). By August the larvæ are mostly full grown and have disappeared to the ground, where they pupate, remaining in the pupa stage (fig. 24) until the following May or June. Both caterpillars and moths (fig. 24) are rather striking in appearance, and there should be no difficulty in their recognition.

FIG. 23.—Larva of 8-spotted forester. Somewhat enlarged.

CONTROL.

The eight-spotted forester can be readily controlled by the use of arsenical sprays, such as arsenate of lead applied to the plants as soon as injury is first in evidence. The arsenical should be used, preferably in Bordeaux mixture, as described in the spraying schedule (p. 74), or may be applied in water at the rate of 1 pound of the powder or 2 pounds of the paste to 50 gallons of water. For small amounts use the powdered form at the rate of about 1.5 ounces to 5 gallons of water.

FIG. 24.—Pupa and moth of 8-spotted forester.

THE GRAPE PLUME MOTH.[10]

During late May and June in the Northeastern States the caterpillars of the grape plume moth frequently attract attention by webbing together the terminal leaves and shoots of grapevines, as well as the blossom clusters (fig. 25). Although distributed over the Atlantic States, it has been the subject of complaint during recent years from New Jersey, southeastern New York, Connecticut, Massachusetts, and Rhode Island.

Within the webbed-up terminal growth, the greenish hairy caterpillars feed upon the leaves and blossoms, causing some loss in yield of fruit. The caterpillars are likely to be prevalent only in vines around the home and will not as a rule do serious damage. The life

[10] *Oxyptilus periscelidactylus* Fitch.

history of this insect is imperfectly known, as its injuries thus far have not been sufficiently important to require its careful study. Hand picking and destroying the webbed leaves with the contained larvæ should keep the insect in check in home plantings. Little, if any, loss from this pest is likely in commercial vineyards.

THE BROWN GRAPE APHIS.[11]

The brown grape aphis infests the tender growing shoots and leaves of the grape and when abundant may occur on the fruit clusters. Its dark brown color and relatively large size render it rather conspicuous (fig. 26), and hence it is the subject of frequent inquiry. The insect is common in the Southern States and ranges to Pennsylvania and New York, and westward to Missouri, Oklahoma, and Texas. It is probably a native species, infesting wild grapes, as well as cultivated sorts. It winters in the egg stage, the eggs being laid in the fall by the female on twigs of black haw. Hatching begins early in the spring and continues for two or three weeks. Young aphids feed on the expanding buds of the haw, and later on the flowers, twigs, and foliage. Migrants or winged individuals fly from the haw to wild or cultivated grapes in the neighborhood, where they establish colonies. The aphids continue to infest the grape throughout the summer, producing sometimes more than a dozen generations, though the colonies may become much decimated by the attack of predatory and parasitic insect enemies. In the fall migrants, which give rise to egg-laying females, return to the haw. The latter deposit the winter eggs.

FIG. 25.—Larva of grape plume moth and its injury to grape shoot. Somewhat enlarged.

This aphid has not thus far attracted much attention in commercial vineyards, but is quite prevalent throughout its area of distribution on vines growing around homes. It can be controlled by spray-

[11] *Macrosiphum illinoisensis* Shimer.

ing the infested vines with a contact insecticide, such as 40 per cent nicotine sulphate, fish-oil soap solution, kerosene emulsion, and the like.

THE GRAPE FLEA-BEETLE.[12]

Early in the spring as they are ready to burst, buds of the grape may be eaten into or entirely scooped out by a small blue or greenish beetle (fig. 27), measuring about one-fifth of an inch in length, of robust shape, with thick thighs, which jumps readily from the vines upon being disturbed. This is the grape flea-beetle. If the beetles are abundant, most of the buds on the vines may be destroyed, greatly retarding leafing out and resulting in a material loss of fruit. The insect is sporadic and more or less local in its occurrence in seriously destructive numbers, and these outbreaks are likely to subside as suddenly as they appear.

FIG. 26.—The brown grape aphis on grape shoots.

The females deposit their eggs largely in cracks in the bark at base of buds, between bud scales, or even in the holes which have been eaten into the buds (fig. 28). The larvæ hatch in a few days and feed on the leaves of the grape, mainly on the upper surface, and are thus readily destroyed with sprays (fig. 29). In three or four weeks, when the larvæ have attained full growth, they drop to the ground, construct an earthen cell an inch or so below the surface, and transform to pupæ, the adult beetles emerging in the course

[12] *Haltica chalybea* Illiger.

of one or two weeks. The new brood of beetles feed upon the foliage of the grape and other plants, going into hibernation in the fall under trash in and around vineyards, appearing the next spring in time to attack the swelling buds of the grape. This flea-beetle is a native species and occurs very generally throughout the eastern half of the United States, its western limits being Minnesota, Nebraska, Kansas, and Texas. In addition to cultivated and wild grapes, it has been reported as feeding on Virginia creeper, plum, apple, pear, quince, blue or water beech, elm, etc.

FIG. 27.—The grape flea-beetle. Much enlarged.

CONTROL.

Vineyards regularly sprayed with arsenicals and Bordeaux mixture for other grape pests are not so likely to be injured by the flea-beetle as are others. The insect thrives best in neglected vineyards, and in these may become quite abundant and destructive. Where it is desired to treat for this insect only, as during outbreaks, the vines should be thoroughly sprayed with an arsenical just as the buds are beginning to swell, or somewhat earlier. A close lookout must be kept for the first signs of the beetles and the poison applied immediately. Delay of a day or so may mean the loss of the buds, and hence serious injury to the fruit crop. In the small home vineyard it will often be practicable to search out the beetles during the morning, when they are sluggish, and remove them by hand. Destruction of the larvæ when feeding on the foliage may be effected by the use of an arsenical, such as arsenate of lead. In spraying for the adults, or beetles, the poison should be used stronger than ordinarily—that is, 2 pounds of the powdered arsenate of lead or 4 pounds of the paste to each 50 gallons of spray.

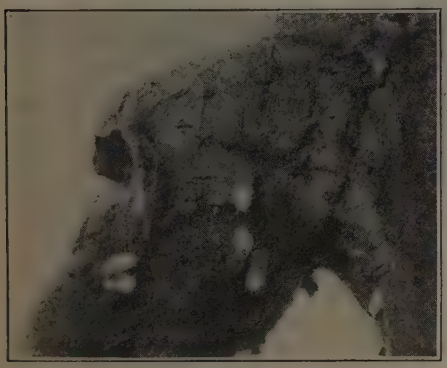


FIG. 28.—Eggs of grape flea-beetle. Much enlarged.

THE GRAPE LEAF SKELETONIZER.[13]

The grape leaf skeletonizer is noted usually on vines grown around the home. Owing to the general spraying of commercial vineyards, it is rarely seen in these and practically never in such abundance as to cause serious injury. The insect occurs rather generally from the eastern United States west to Missouri and Arizona. The larvæ in their earlier stages feed in a characteristic manner, usually upon the upper surface of the leaf. Starting from a common point, the larvæ feed side by side, soldierlike, retreating as they feed until the leaf tissue is destroyed. Young larvæ eat out the parenchyma or soft leaf tissue, leaving the skeleton framework of the leaf intact. Full-grown larvæ, however, consume the leaf substance entirely, leaving only the larger veins (fig. 30). The full-grown larva is a little more than one-half inch in length, sulphur-yellow in color, slightly hairy, and having on each body segment four black tubercles, showing above as four distinct longitudinal rows. It is native to this country, and in addition to grape feeds on various wild plants, including Virginia creeper. The insect winters in the pupa condition in oblong-ovate cocoons in fallen leaves or trash around the vines. Rather late in the spring the moths emerge and deposit small, lemon-yellow eggs in clusters or masses, ranging from a few to over 200, usually on the lower surface of the leaves. The resulting larvæ require some 40 days to complete their growth, and the time spent in the cocoon during the summer is about 10 days. The complete life cycle from egg to the death of moths is about 66 days. Second generation larvæ are present over a considerable period of the summer, and this fact led earlier writers to believe there were two generations and a partial third each year.

FIG. 29.—Grape flea-beetle larva and its work on grape leaf.

CONTROL.

Under ordinary conditions of abundance, hand picking and destruction of infested leaves will be sufficient to keep the insect in

[13] *Harrisina americana* Guér.

check. When occurring in numbers they can be easily and promptly destroyed by spraying with an arsenical, such as arsenate of lead. (See p. 65.)

CLIMBING CUTWORMS.

Several species of cutworms are known to attack the grape, and instances are recorded of serious damage resulting from their eating out the swelling buds in the spring (fig. 31). Injury of this char-

FIG. 30.—Larva of grape leaf skeletonizer on grape leaf.

acter has frequently been reported in recent years in portions of the San Joaquin Valley, Calif., especially in vineyards permitted to become more or less grown up with weeds and grasses the preceding fall. The plowing under of such vegetation forces many of the hungry caterpillars to the vines for food, and the buds and foliage are attacked.

CONTROL.

Cutworms will not as a rule cause important injury in vineyards kept reasonably free from grass and weeds throughout the growing

season. When found destructive, poisoned baits should be employed as for the destruction of these insects in gardens. A poisoned bait may be made as follows: Dry bran, 1 peck; white arsenic or Paris green, 4 ounces.

The above is to be mixed thoroughly with 2 gallons of water, into which has been stirred one-half gallon of sorghum or other cheap molasses. After the mash has stood for several hours it should be scattered in lumps the size of marbles over the area where the cutworms are injurious. Apply late in the day, since the larvæ are active at night. For large-scale work the poisoned mash may be made up in any desired quantity according to the same formula.

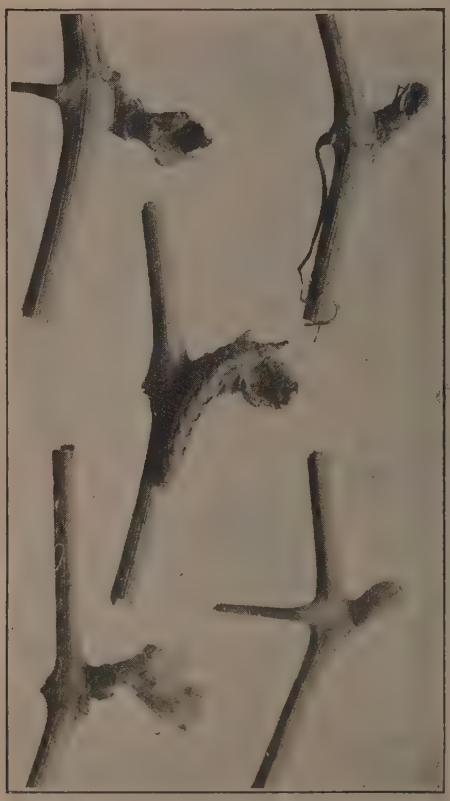


FIG. 31.—A climbing cutworm and its injury to grape buds.

Grapevines around the home can be protected by fastening around the trunk several inches from the ground a collar of cotton batting or wool, which effectively prevents the larvæ from ascending the vines. The cotton batting may become more or less compacted after heavy rains and its value considerably reduced. This defect can be obviated in a measure by using bands 5 inches wide, tying with a string at the bottom, and turning the upper part of the band down over the lower edge.

A little searching in the soil around the base of vines will often bring to light the larvæ, which can be destroyed.

FLY GALL-MAKERS.

Galls of various kinds occur on the grape as a result of attack of unrelated species of insects, as the grape phylloxera (pp. 45–47), the

grape cane gall-maker (p. 39), the vine Erinose, etc. There is a series of galls resulting from the work of small midges, or gnatlike flies, to be found on leaves, tendrils, blossom buds, and blossom clusters, which are sufficiently abundant some seasons to cause considerable injury, though as a rule their importance is not great. These small flies are representatives of a large family of insects which produce galls on many widely different plants. Although numerous species of gall midges attack the grape, the following will serve as examples of these insects and their injuries:

FIG. 32.—Grapevine tomato gall on grape blossom.

THE GRAPEVINE TOMATO GALL.[14]

The grapevine tomato gall with its associate (*Dasyneura vitis* Felt) is probably more complained of than any other attacking the grape. The general appearance of these galls is shown in figures 32 and 33. The irregular, succulent galls occur on wild and cultivated grapes, often in a mass, suggesting at times a group of small tomatoes, and hence the common name. The galls may be on the leaves, leaf stalk, tendrils, or stalks of the fruit clusters. They vary in color from greenish yellow to reddish, the latter color being often the predominant one. When cut open several cells will be found and in each, at the proper time, an orange-yellow larva, the grub or maggot of the parent midge. When mature the grubs escape the galls

[14] *Lasioptera vitis* O. S.

through holes cut to the exterior, and fall to the ground where they change to pupæ and remain until the following spring, the flies developing in time to start other galls on the tender growth.

No practical control for this insect is known. The cutting off and destroying of galls before the grubs have escaped should serve to reduce the attack another season.

THE GRAPE APPLE GALL.[15]

The hazelnut-like grape apple gall occurs on the shoots of the vine. It is somewhat less than an inch in diameter, greenish in color, becoming reddish as the season advances, more or less pear-shaped, and

FIG. 33.—Grapevine tomato gall on grape leaf and tendril.

marked on the outside with depressions extending lengthwise (fig. 34). When cut open it is found to be divided into cells or segments with a cross partition, each cell being occupied by bright yellow larvæ. The gall, succulent when small, later becomes quite hard and woody. Removing the galls by hand and destroying them when found are advised.

THE TRUMPET OR GRAPE TUBE GALL.[16]

The upper surface of grape leaves is frequently found to be more or less covered with nail-like galls about one-third of an inch long. The galls are reddish or crimson in color, shading to green. The par-

[15] *Schizomyia pomum* W. & R. [16] *Cecidomyia viticola* O. S.

ent insect is a small midge, or gnat, resembling the preceding species, and the larva or grub within the gall is pale orange in color. This species is not sufficiently abundant to require treatment.

HAWK MOTHS.

Several species of insects known in the adult stage as hawk moths and in the larva stage as hornworms attack the grape, cultivated and wild, the Virginia creeper, and numerous other plants. As a rule the caterpillars occur in small numbers, stripping the foliage from parts of the vines, though young plants may be entirely defoliated by them. There are records, however, of the local occurrence of certain species in very large numbers completely defoliating large vineyards and requiring prompt action to arrest their ravages. Such

FIG. 34.—The grape apple gall.

an outbreak occurred in Tulare County, Calif., in 1919, involving some 700 acres of vines. Large-scale spraying operations were supervised by the bureau, requiring an outlay of about $11,000, but resulting in saving the crop, valued at $300,000.

The life and habits of the hawk moths attacking the grape are fairly similar. Eggs are laid by the parent moth, usually singly on the leaves, the resulting larvæ attacking the foliage and eating the leaves more or less completely. The young larvæ bear on the caudal end of the body a conspicuous horn-like process which may persist in the full-grown caterpillar, or be replaced by an eye spot, according to species. When mature, the larvæ go to the soil, change to brown pupæ, and pass the winter in this condition. In the case of some species the moths appear again the same season and deposit eggs for an additional generation or generations.

THE ACHEMON SPHINX.[17]

A caterpillar known as the Achemon sphinx is often inquired about, as it is commonly found on grape. It is this species which caused the serious injury in California in 1919, already mentioned. When young the larva is light green in color, with a conspicuous brown horn. The full-grown larva, however, which is about 3½ inches long, is of a straw or reddish-brown color, varying often to pinkish, with six diagonal cream colored stripes along each side, and the horn is replaced by a conspicuous eye spot inclosing a dark spot (fig. 35).

THE HOG CATERPILLAR.[18]

Another common hornworm of the grape is the so-called hog caterpillar. The larva measures about 2 inches in length, is green

FIG. 35.—The Achemon sphinx.

in color, marked with small yellowish dots, and on each side with seven oblique stripes. From the horn to head along the back is on each side a wide dark green stripe. There are a number of broods each year and larvæ of the later broods are likely to be pinkish in color. The hog caterpillar is said to be very voracious, a few larvæ when nearly grown being capable of completely defoliating vines, and they are accused of biting into the stems.

THE WHITE-LINED SPHINX.[19]

The white-lined sphinx also attacks the grape and numerous other plants. It likes parsley, on which it multiplies, later attacking the grape. The larva is about 1½ inches long, varying much in color and markings. Some are yellowish green, while others are almost black with markings along the sides and a yellow line along the dorsum.

---

[17] *Pholus achemon* Drury. [18] *Ampelophaga myron* Cramer. [19] *Deilephila lineata* Fab.

CONTROL OF HORNWORMS.

Vineyards sprayed with arsenicals for other grape insects will be little troubled as a rule by hornworms. Injury is likely to be evident in small unsprayed vineyards or on vines growing around the home. Thorough spraying of the plants with arsenicals should at once check the ravages of these insects. In the case of serious outbreaks in commercial vineyards, prompt measures are essential to obviate injury to the crop through the destruction of the leaves. A formula found effective in the outbreak in Tulare County, Calif., during 1919, is powdered arsenate of lead, 12 pounds; nicotine sulphate containing 40 per cent nicotine, 1½ pints; water to make 200 gallons.

INSECTS AFFECTING THE CANES.

THE GRAPE SCALE.[20]

The grape scale has frequently been reported on grapevines, though it has not usually been so abundant as to cause serious injury. From the vicinity of the District of Columbia, however, frequent reports have been received during recent years, with specimens indicating its destructive work, particularly in small home vineyards, and to a small extent in commercial plantings. The grape scale attacks the wild grape, Virginia creeper, hickory, sycamore, and perhaps other trees. The insect is widely distributed in the eastern United States, ranging from Florida to New Jersey, westward to Missouri and Kansas, and has recently been found in California. It has also been reported from Brazil and the West Indies.

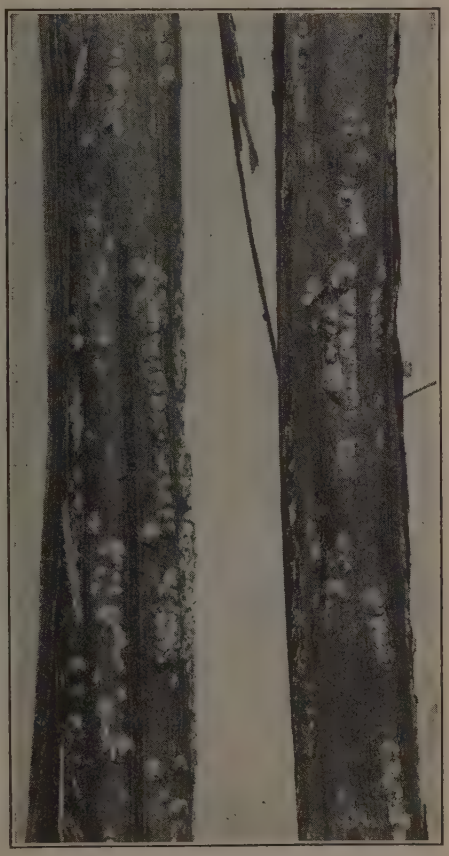


FIG. 36.—The grape scale on grape canes. Enlarged.

[20] *Aspidiotus uvae* Comst.

Badly infested vines have a dirty white, whitewashed appearance, the infestation occurring on the 2-year-old canes. When abundant the scales materially check the growth of the vines. The rate of spread of the insect is slow, however, as the insect has been observed to occur for several seasons on a given vine in a row without spreading to adjacent vines. During May and June there develop from the parent insect some 35 to 50 living young which, after a brief period of activity, settle down on the canes, mostly in rows under the exfoliated bark of the previous season's growth (fig. 36). By fall the scales are nearly grown, and in this condition they pass the winter. There is probably but one brood each year.

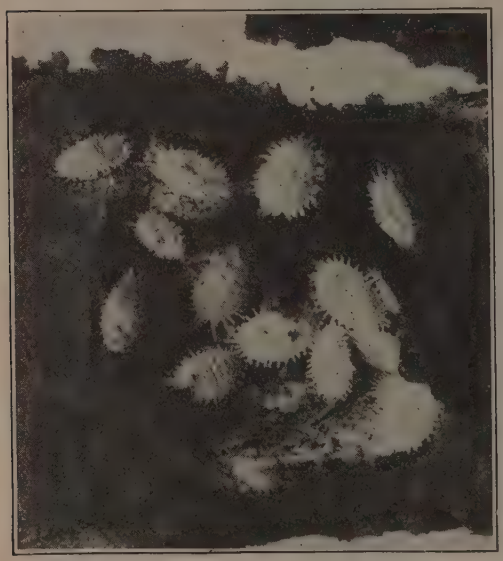


FIG. 37.—A mealybug. Considerably enlarged.

CONTROL.

The grape scale is not difficult to control. The best treatment consists in the thorough application during the dormant period of winter-strength lime-sulphur wash as used for the San Jose scale. Previous to the application of the spray, loose bark should be removed from the vines as much as practicable, since many of the insects are well protected by the shreds of bark. This scale will also yield to applications of strong soap washes and kerosene emulsion.

THE GRAPE MEALYBUG.[21]

The grape mealybug (see fig. 37, illustrating a related species) has recently become known as a pest of grapes in California, especially in the counties of Fresno and Kings. Infestation of grapes has also been noted elsewhere in the State. The damage is not done by attack of the insects on the plant, but results from the soiling of the fruit by the copious honeydew voided by the mealybugs in the course of their feeding. This excrementitious matter accumulates on the fruit in various sized drops, causing the adherence of dirt, wax, and cast skins of the insects. It largely prevents use of the fruit as table

[21] *Pseudococcus bakeri* Essig.

grapes, and when the infestation is considerable it is not suitable for raisins. (Fig. 38.)

The insect upon hatching into the larva stage passes the winter, without further development, within the ovisac made by the female when depositing the eggs. With the first warm days of spring the larvæ leave the ovisac and make their way to the vine, settling down under the loose bark, in crevices, etc., where the tender bark of the grape is exposed. The spring brood of mealybugs mature in June and eggs are again deposited by the females. The young of this sec-

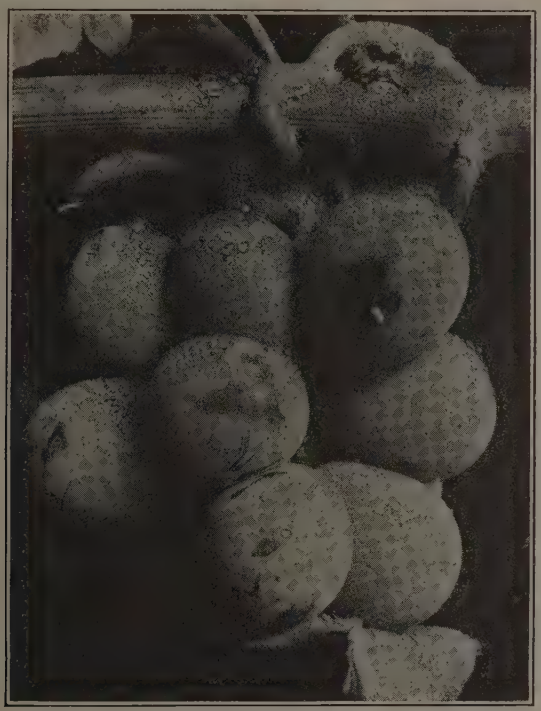


FIG. 38.—Accumulation of honeydew on grape cluster following presence of grapevine mealybug.

ond or summer brood feed on the tender canes and foliage and when nearly grown are to be found in the bunches of grapes, soiling these as described. During September and October females again deposit eggs, the larvæ hatching but remaining in the cottony ovisac over winter.

In its food habits the insect is practically omnivorous, and the grape is probably not especially suited to it as a host plant. The insect is averse to light and infests the vines where the dense foliage affords shade and the succulent fruit abundant food.

CONTROL.

The presence of honeydew on grapes at harvest time is usually proof of mealybug infestation, though the insects themselves may be so well hidden within the grape cluster as to escape ready detection. Honeydewed fruit should be excluded from the pack and promptly removed from the vicinity of the packing house, along with other cull grapes. Grape pickers should be instructed to exclude from the picking boxes bunches of grapes showing honeydew. Care should be taken to disinfect picking boxes by submerging them in hot water, by fumigation, or otherwise. The destruction of the insects in the vineyards offers difficulties. It is under investigation at the present time by the Bureau of Entomology and it is hoped that soon a practical control will be determined.

FIG. 39.—Grape cane-borer and its injury to pecan. Enlarged.

THE GRAPE CANE-BORER.[22]

The presence of the grape cane-borer in vineyards is usually first disclosed by the sudden wilting or breaking off of shoots in the spring. An examination of the canes will show a round hole opening into a burrow in the main stem (fig. 39, injury to pecan), in which will usually be found a cylindrical brown beetle about three-eighths of an inch long, with head set well under the body and the posterior end abruptly cut off and bearing a pair of horn-like protuberances (fig. 40). The beetle attacks a variety of fruit trees, including apple, pear, peach, plum, pecan, and certain forest and shade trees, but is most troublesome to the grape. The species is generally distributed in the United States and Canada east of the Rockies, but is most complained of in certain Mississippi Valley States, as Arkansas, Missouri, Texas, Iowa, Kansas, and Nebraska. On the Pacific Coast a related form occurs, working in about the same way. Injuries by this species are due to the apparently malicious borings of the adult beetle in grape canes, resulting in the wilting or dying of adjacent shoots, since the grubs breed in drying wood of shade and fruit trees, drying grape canes, or exposed roots of maple, etc.

[22] *Schistocerus hamatus* Fab.

There is only one generation of the insect each year, larvæ maturing by fall and mostly pupating and developing to the beetle stage, in which condition the winter is passed.

CONTROL.

The grape cane-borer is best kept in check by giving attention to the destruction in and around vineyards of dying trees, prunings, and the like, which are necessary for the development of the young. After the canes are bored into nothing can be done to correct the damage. It may be practical in some cases to destroy the beetles in their burrows by use of a curved wire. During warm days the adults are likely to be out of their burrows and can often be gathered by hand and destroyed.

FIG. 40.—Grape cane-borer. Considerably enlarged.

THE GRAPE CANE GALL-MAKER.[23]

A small, reddish brown weevil, the grape cane gall-maker, sometimes punctures with her snout the shoots of the grape, usually just above one of the lower joints; in this puncture an egg is placed and several additional punctures may be made above the first, but in these no eggs are deposited. The larva upon hatching feeds in the pith, burrowing up and down the shoot. When full grown the pupa stage is entered in the burrow, the beetle emerging in midsummer. As the shoot grows it becomes enlarged at the punctured place, resulting in a gall-like swelling about twice the diameter of the cane in thickness and one or two inches in length. The injured canes continue to grow and, unless broken by winds, little harm results. No practical methods of preventing injury by this insect have been developed and ordinarily its attack is of very little importance.

THE GRAPE CANE-GIRDLER.[24]

The grape cane-girdler is a very near relative of the preceding species and has about the same life history. The egg-laying activities of the female practically girdle the shoots, which soon drop (fig. 41). The egg is deposited mostly at the joint next below where the shoot has been cut off. Cutting off and destroying the shoot a few inches below this joint will result in the destruction of the grub feeding on the pith within the shoot.

[23] *Ampeloglypter sesostris* Lec. [24] *Ampeloglypter ater* Lec.

INSECTS AFFECTING THE ROOTS.

THE GRAPE ROOTWORM.[25]

The grape rootworm, as the name indicates, infests the roots of the grape, devouring more or less completely the small roots and rootlets and eating pits and burrows into the outer portion of the larger roots. It is the larva of a small, hairy, chestnut-brown beetle (fig. 42) which makes its appearance in vineyards at about the close of the blooming period of such varieties of grapes as Concord, Niagara, Catawba, etc. The beetles feed freely on the upper surface of the leaves, eating a series of patches or holes through to the lower surface, thus producing characteristic chain-like feeding marks, as shown in figure 43, by which their presence in vineyards can be readily detected. The injury to the foliage, however, is quite unimportant compared to the work of the larvæ on the roots (fig. 44). When the larvæ or grubs are abundant the vines may be killed in the course of two or three seasons, but usually the plants will linger, though making but a feeble growth and failing to produce profitable crops. The death of vines or gradual failure of a vineyard should call for an examination in late spring of the foliage for the characteristic feeding marks of the beetle, and of the roots for the work of the larvæ on these parts.

FIG. 41.—Grape cane-girdler and its injury to grape shoot.

FIG. 42. The beetle or parent of the grape rootworm. Considerably enlarged.

The insect is a native species, feeding originally on wild grapes, as it does at the present time. In addition to wild and cultivated

[25] *Fidia viticida* Walsh.

varieties of grapes, it has been reported as feeding on Virginia creeper and the American red-bud. It is widely distributed in the Mississippi Valley and the Eastern States, and has been recorded as destructive in Kentucky, Missouri, Arkansas, Illinois, Ohio, Pennsylvania, and New York. It has been particularly injurious in northern Ohio, Erie County, Pa., and western New York. The insect thrives in vineyards which have been neglected. In the absence of cultivation and timely spraying it may become a serious pest in any vineyard throughout its range of distribution. This is especially true in light gravelly soils and in regions where grape growing is followed on a large scale.

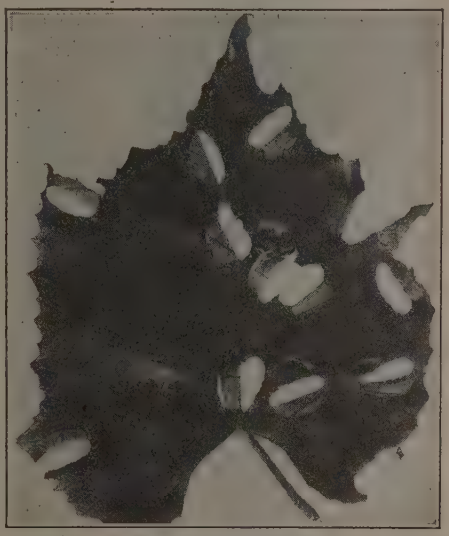


FIG. 43.—Feeding marks on grape foliage of the grape rootworm beetle.

LIFE HISTORY AND HABITS.

The adults make their appearance in vineyards, beginning about the close of the blooming period. In New York, Pennsylvania, and Ohio grape districts, emergence begins the latter part of June or in early July, varying with the season and soil. After emergence beetles begin to feed, eating rows of holes in the upper surface of the leaf, as described. Shortly the females begin to deposit eggs, the number for an individual female varying considerably, but averaging about 100. Eggs are deposited in patches under the bark of last year's wood and may be placed quite generally over the canes (fig. 45). In about 8 to 14 days the eggs here hatch and the resulting larvæ drop to the ground. Although their powers of locomotion and endurance are considerable to enable them to overcome difficulties in reaching the roots, many doubtless fail to do so and perish. When established on the roots, however, the grubs feed freely and grow rapidly, and by fall the majority of them are full grown or nearly so (fig. 46). The insect hibernates in the grub stage several inches deep in the soil. In the spring the larvæ ascend to near the surface of the earth, the immature ones complete their growth, and the pupa stage is entered, mostly at from 2 to 3 inches below the surface of the ground and within a radius of 1½ to 2 feet from the base of the vine. An earthen cell is prepared by the larva in which the pupa or "turtle" stage is passed (fig. 46). The insects in this condition are

soft and helpless, and a stirring of the soil close along the rows by cultivation, as with the so-called horse-hoe, is doubtless fatal to many of them. Pupation is perhaps at its height just before the grape blossoms, though this time may be determined with some exactness by examination of the insects in the soil. The grape rootworm has several natural enemies, which in the aggregate do considerable to keep it reduced.

FIG. 44.—Injury by grape rootworm to roots of grapevine.

CONTROL.

Since the adults feed freely on the foliage for some days before egg laying, they can be destroyed by thorough spraying of the vines with an arsenical, such as arsenate of lead. This should be used at the rate of 1½ pounds of the powder or 3 pounds of the paste form to each 50 gallons of spray. The poison should be applied in Bordeaux mixture necessary for the control of fungous diseases. According to experiments by the Geneva, N. Y., agricultural experiment station the effectiveness of the spray is greatly increased by the addition of 1 gallon of molasses to each 50 gallons of liquid, though its adhesiveness is much lessened, and care should be taken to apply it when weather conditions are favorable, and repeat after heavy rains. The first application should be given shortly after the first beetles or their feeding marks are to be seen on the leaves, and the second treatment about 10 days later.

While the time of treatments for best control of the grape rootworm and the grape leafhopper do not exactly coincide, yet under average conditions of abundance of these two pests they should be kept in check by a combination application of arsenate of lead and nicotine in Bordeaux mixture (see schedule, pp. 74–75). Where

either pest is unusually abundant, spray applications should be made according to recommendations for that particular insect.

To offset as much as possible the injury of the grubs to the roots of vines in badly infested vineyards, care should be given to adequate cultivation, fertilization, and pruning. Severely injured vineyards, by improved care in these respects, together with spraying, have been brought back to a condition of satisfactory productivity in two or three seasons.

FIG. 45.—Egg mass of grape rootworm beetle.

THE CALIFORNIA GRAPE ROOTWORM.[26]

Another rootworm attacks the grape in California in a way very similar to its eastern relative, the grape rootworm. This insect, though widely distributed in the United States, seems to confine its attack to vinifera or European grapes in California. It occurs in Europe, Algeria, etc. In parts of Europe it is a pest of importance to the grape.

The remedial measures indicated for the control of the grape rootworm are applicable in the case of this species.

THE GRAPEVINE ROOT-BORER.[27]

Injury by the grapevine root-borer is confined to the roots of the grape, in which channels or burrows are eaten, or the roots often an inch or more in diameter may be girdled (fig. 47). In severe cases most of the main roots may be severed, leaving only a stub or mere stump, thus greatly reducing or destroying the vigor and productivity of the vines. The insect, so far as known, attacks the grape exclusively, wild or cultivated. It is inconspicuous in all its stages and thus is likely to be overlooked, the attack of larvæ on

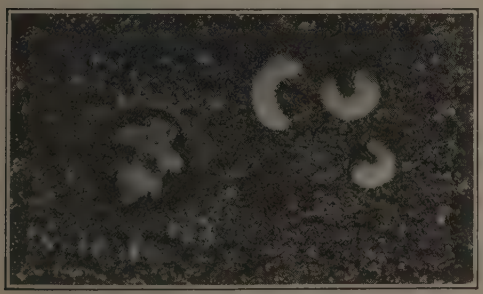


FIG. 46.—Grubs and pupæ of grape rootworm.

[26] *Adoxus obscurus* L. [27] *Memythrus polistiformis* Harris.

the roots usually being first indicated by the unthrifty condition of the plants. The grape root-borer has been recorded from Kentucky, Minnesota, Missouri, North Carolina, Maryland, Ohio, West Virginia, and Vermont, and probably occurs elsewhere in the Middle West and in the Eastern States. Its most serious attacks have been in West Virginia, North Carolina, and Kentucky. The adult is a wasplike moth (fig. 48), a near relative of the so-called peach borer. The moths begin to appear from pupæ in the soil about the middle of July and continue to emerge until about the middle of September. The eggs (fig. 49) are deposited on the leaves and canes of the grapevine and very frequently on grass, weeds, or trash surrounding the plants. The resulting larvæ burrow into the soil and attack the larger grape roots and are able to penetrate the earth for a considerable distance in their search for food. The larvæ pass the winter in chambers or cells at the ends of their burrows in the roots. Feeding is resumed with the approach of warm weather in the spring. Upon completion of growth a cocoon is made, the pupa stage is entered (fig. 50), and the moths begin to emerge about the middle of July, as stated.

FIG. 47.—Larvæ and injury to grape roots by the grapevine root-borer.

FIG. 48.—Parent or moth of grapevine root-borer. Enlarged.

METHODS OF CONTROL.

This species can not be controlled by usual insecticidal practice in vineyards. Thorough cultivation of the vines during June and July is probably beneficial in destroying some of the larvæ, but by far the most valuable method is maintaining the plants in a vigorous and

healthy condition by adequate fertilization, pruning, spraying, etc. In this way the infested vines are most likely to be kept in a productive condition in spite of the attack of the insect.

THE GRAPE PHYLLOXERA.[28]

FIG. 49.—Eggs of grapevine root-borer. Considerably enlarged.

The grape phylloxera has come into wide notoriety on account of its injurious relation to vinifera or European varieties of grapes. It is a native of the United States approximately east of the Rocky Mountains, where it lives on various wild species of American grapes and attacks more or less cultivated varieties. The phylloxera was introduced into France presumably on vines from America some time previous to 1867 and quickly became a most serious menace to the grape-growing industry. By 1884 a third of the vineyard area of France had been destroyed and much additional territory seriously injured. The phylloxera has spread to much of the vine-growing regions of Europe, and occurs in Russia, Algeria, and New Zealand. In California, where European or vinifera varieties of grapes are largely grown, the phylloxera has been for many years the most important insect enemy of the vine (fig. 51). It made its advent into that State about 1858 and was presumably introduced on American grapes from the Mississippi Valley or Eastern States. At the present time the insect in the United States is a pest of importance practically only in California, though reports of injury, especially to foliage (fig. 52), have occasionally come from States east of the Rockies, principally on varieties with considerable vinifera blood. Our wild grapes in the East possess in varying degrees immunity from injury by the phylloxera and thrive in spite of the presence of the insect. In Europe, California, and elsewhere the ravages of the phylloxera are now being circumvented by the use of American

FIG. 50.—Cocoon and pupal skins of grapevine root-borer. Enlarged.

[28] *Phylloxera vitifoliae* Fitch.

resistant vines for stock for vinifera sorts, and for some years new vineyard plantings have been of vines of this character.

In the protection of vineyards on vinifera or other nonresistant roots, direct remedial measures are employed, as the use of fumigants, such as carbon disulphid, the flooding of vineyards for stated periods, etc. A very large amount of experimental work has been done in determining the best resistant stocks and best remedial measures for the phylloxera, especially in France.

FIG. 51.—Phylloxera injury to vinifera vineyard in California.

The life history of the phylloxera is quite complicated and varies considerably, according to type of grape infested and the climate of the country inhabited by it. The phylloxera may be disseminated from nurseries on vines, or on vines from infested vineyards, and new centers of infestation come about principally in this way. In California spread from these centers is due to migration from infested vines over the soil, or through cracks in the soil of the small root-inhabiting nymphs or larvæ (fig. 53). These small larvæ may also be borne by wind and by picking boxes, and in hilly or irrigated vineyards perhaps some are carried by water. The winged form in

that State appears not to be a factor of importance in the dissemination of the species.

CONTROL.

Growers of American varieties of grapes, with a few exceptions, will not find the phylloxera of sufficient importance as a pest to require consideration. Those planting vinifera sorts should use vines on resistant stocks. The kind of stock which should be employed varies with the variety of grape to be grown and other conditions, and expert advice on this subject should be obtained from the viticul-

FIG. 52.—Leaf galls of grape phylloxera as found in eastern United States.

turist of the Department of Agriculture or of the University of California.

In California the use of carbon disulphid injected into the soil to destroy the insects on the roots is, in most instances, impracticable, as is also the utilization of water in flooding vineyards.

FUNGOUS DISEASES.

Most of the fungous parasites of the grape are indigenous, and came originally from the native wild vines. With the gradual extension and development of the grape-growing industry there has also been an increase in the distribution and destructiveness of these fungous diseases. The conditions which necessarily obtain in com-

mercial grape culture have disturbed the equilibrium which had become established between the vine and its parasites in their wild state, and have facilitated the reproduction and distribution of the diseases. In the selection and breeding of the grape attention has been devoted chiefly to the improvement of the fruit, and this has apparently resulted in some cases in a decrease of the natural powers of resistance to disease originally possessed by the wild vines.

FIG. 53.—Colon of grape phylloxera and its distortions on vinifera grape root. Considerably enlarged.

In certain sections of the country where grape growing was once a profitable industry it has largely been abandoned, chiefly on account of the great loss caused by disease. The amount of loss from fungous diseases of the grape in the United States varies greatly from season to season, according to conditions, varieties, and treatment. In the past they have frequently, in certain localities, caused a total loss of the crop when no preventive measures have been taken. The principal cause of the failure of the early American fruit growers in their attempts to grow the European varieties of grapes seems to have been the severe and destructive attacks of our native fungous diseases to which the vinifera grapes were more susceptible than the native varieties.

Injury due to fungous parasites depends largely upon weather conditions. The conditions most favorable for the development of the majority of the fungous diseases are excessive moisture and heat. The general physiological condition of the vines is also important. Vines which are kept thrifty and vigorous by proper care and cultivation are not likely to suffer as severely from most diseases as those which are neglected. Different varieties also show different degrees of susceptibility to the different diseases.

The principal fungous diseases in the order of their importance are black-rot, downy mildew, powdery mildew, anthracnose, ripe-rot, dead arm, and crown gall. There are also some minor diseases, but

they are not of sufficient economic interest to require much attention here.

No attempt will be made here to treat of the nonparasitic diseases or those of obscure or unknown cause, such as the Anaheim or California vine disease, Little leaf, and Spanish Measles. These diseases are at present restricted to the European varieties and hybrids grown in the Pacific coast region, and no satisfactory methods of prevention or control are yet known. Their causes must first be determined by thorough research.

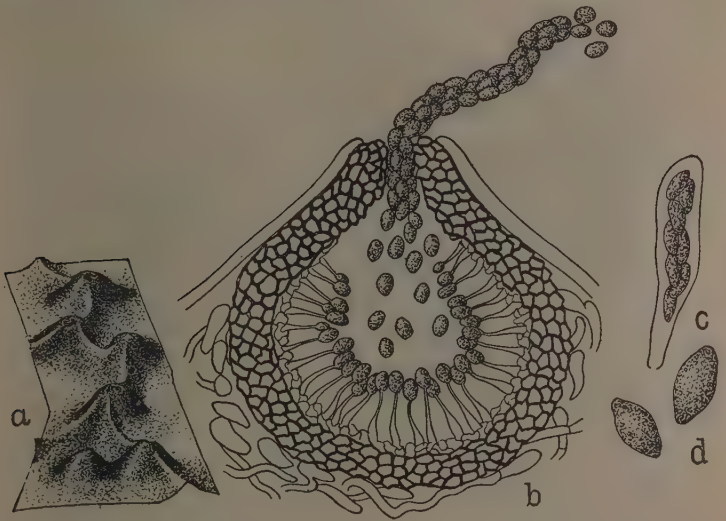


FIG. 54.—The black-rot fungus: *a*, A portion of an affected grape, showing the pustules in which the spores are produced (slightly magnified); *b*, a section of one of these pustules very highly magnified, showing the manner in which the summer spores are produced and discharged; *c*, a sac containing winter spores; *d*, single winter spores very highly magnified.

BLACK-ROT.

In the region east of the Rocky Mountains black-rot is the most generally distributed and destructive fungous disease of the grape. It does not occur in the arid regions of the West. It is caused by a parasitic fungus.[29] It gains entrance to the plant by means of minute germs called spores. These are borne in small black fruiting bodies as shown in figure 54, *a*, *b*, and can not be seen with the naked eye. They are distributed chiefly by the wind and rain. Two or more forms of spores are produced, as shown in the accompanying illustration (fig. 54, *c*). When these spores come in contact with the young and tender parts of the vine, under favorable conditions,

[29] *Guignardia bidwellii* (Ell.) V. & R.

they germinate and produce a slender germ-tube, which penetrates the tissue and may destroy it.

This disease attacks the leaves and shoots, as well as the fruit. It usually makes its first appearance on the leaves and young shoots, producing reddish-brown dead spots. The fungus may attack the blossoms, as shown in figure 55, or young fruit, this being especially true in case of the Scuppernong grapes, but usually the disease does not attract much attention until the berries are half grown or more. Livid or brownish, soft spots first appear; these spread and soon involve the whole berry, which later becomes black and shriveled or mummied, as shown in the accompanying illustration (fig. 56).

FIG. 55.—*A*, Two bunches of grape blossoms from an unsprayed check plat almost entirely destroyed by black-rot before blossoming. *B*, A sprayed bunch from the same vineyard showing no damage from rot. Natural size.

These diseased berries remain attached to the bunch and their surface becomes covered with minute black pustules, which contain the summer spores of the fungus. During the winter and spring another form, called the winter or resting spore, is produced upon these old, shriveled berries (fig. 54, *c*, *d*). These spores help to carry the disease over from one season to another. It is, therefore, desirable to destroy by burning or plowing under all diseased fruit and leaves as early in the spring as possible.

TREATMENT.

This disease can be effectually controlled by thorough spraying with Bordeaux mixture, as has been demonstrated by the Bureau of Plant Industry. (See spray schedule, p. 74.)

Covering the bunches of grapes with paper bags soon after the blossoms fall is usually an effective means of preventing black-rot and most other fungous diseases of the fruit. It is generally regarded as too laborious and expensive a method for large vineyards, but may be profitably practiced where only a small number of vines are grown or where special market conditions or prices make it advisable.

FIG. 56.—*A*, An average bunch of grapes, showing the proportion of rotten berries (90.7 per cent), in an unsprayed plat. *B*, An average bunch of grapes, showing the proportion of rotten berries (4.3 per cent) in a sprayed plat in the same vineyard. Three-fourths natural size.

DOWNY MILDEW.

Downy mildew [30] in certain seasons and in northern localities sometimes causes more loss than black-rot and is a close rival for first place among the fungous enemies of the grape. It attacks all the tender, growing parts of the vine. Usually it is at first most noticeable on the foliage, producing greenish yellow, irregular spots upon the upper surface, which become reddish brown. At the same time there appears on the under surface of the leaf, a thin, loose, white, downy growth, suggestive of hoarfrost (fig. 57). This growth consists of the fertile fungous filaments bearing the summer spores (fig. 58, *a*, *b*), which, under favorable conditions, are distributed by wind and water to the berries and other parts, where they germinate and produce zoo-

[30] Caused by *Plasmopara viticola* (B. & C.) Berl. & De Toni.

spores, which penetrate the tissues, and continue their destructive work. The young shoots are sometimes attacked and killed.

The fruit, if attacked when young or only partly grown, shows first a brownish spot, and later becomes covered with the gray, downy

FIG. 57.—A grape leaf attacked by the downy mildew, showing the appearance of the leaf above and below.

growth of the fungus. This form of the disease is sometimes called "gray-rot" by vineyardists (fig. 59). When the berries escape the disease until they are half grown or more it appears as a brown or brownish purple spot which spreads and soon involves the whole berry. The affected fruit becomes soft and wrinkled and falls to the

ground when disturbed. This stage of the disease is sometimes called "brown-rot."

Besides the summer spores mentioned, there is also produced within the diseased tissues of the leaves another form of reproductive body, sometimes called a winter or resting spore. These spores are produced in much smaller numbers than the summer spores and are provided with a rather thick, dark-colored outer covering apparently intended for their protection during the winter.

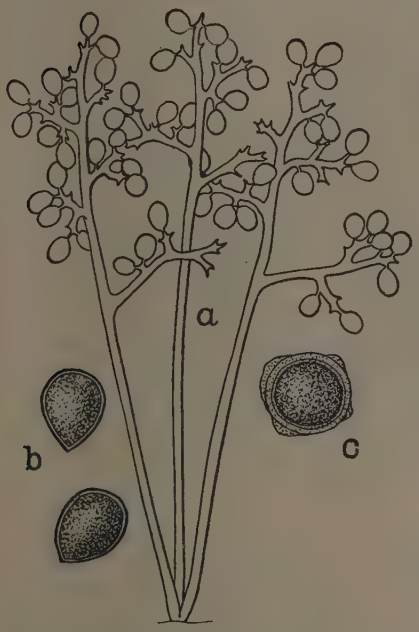


FIG. 58.—The fungus causing downy mildew. *a*, Fertile filaments of the downy mildew fungus, showing the manner in which the summer spores are borne; *b*, two summer spores; *c*, a winter, or resting spore. (All highly magnified.)

FIG. 59.—A bunch of young grapes partially destroyed by "gray-rot." This is a form of the downy mildew affecting the very young fruit.

This disease, like the black-rot and many others, develops most rapidly and does most injury during hot, wet weather and does not cause trouble in arid regions.

TREATMENT.

It is desirable to destroy as many as possible of the old diseased leaves, shoots, and berries, which may contain the winter spores. Thorough spraying on the under sides of the leaves, as recommended for the black-rot, will effectively control this disease.

POWDERY MILDEW.

The powdery mildew [31] rarely causes great loss to American varieties of grapes. It is most severe on the European, or vinifera, grapes. This mildew belongs to a group of fungi quite different from the downy mildew. It differs from all other parasites which attack the grape in its superficial habit of growth. The parasite obtains its nutriment by means of suckerlike organs which penetrate the cell walls of the surface layer of tissue only. The fine, white filaments of the fungus, which constitute the vegetative portion of the parasite, spread over the surface of the leaves, shoots, and fruit, and send up short, irregular branches upon which immense numbers of summer spores are produced in short chains (fig. 60, *a*). These are

FIG. 60.—The fungus causing powdery mildew: *a*, A fertile filament of the fungus bearing a chain of summer spores; *b*, a spore case, in which the winter or resting spores are produced; *c*, a single sac containing winter spores; *d*, a single winter spore. (All highly magnified.)

most noticeable upon the upper surface of the leaf, giving it a fine gray, powdery, or mealy appearance. Finally the affected part of the leaf becomes light brown, and if the disease is severe the leaves fall. The fungus produces a similar appearance upon the young shoots. Berries which are attacked take on a gray, scurfy appearance, become specked with brown, and fail to mature properly. Affected grapes when nearly half grown sometimes burst open on one side, exposing the seeds. The fruit does not become softened and shrunken as when attacked by the downy mildew.

Besides the summer spores, winter or resting spores are also produced in the latter part of the season. These are borne in sacs which are inclosed in minute, black, globose fruiting bodies furnished with slender appendages curled at their tips (fig. 60, *b*, *c*, *d*). These black

[31] Caused by *Uncinula necator* (Schw.) Burr.

spore cases are so small that they can scarcely be seen with the naked eye, but by the aid of a hand lens they can be easily observed. This is the principal fungous disease of the vinifera grapes on the Pacific slope.

TREATMENT.

For American varieties east of the Rocky Mountains, where black rot and downy mildew are usually prevalent, Bordeaux mixture should be applied as recommended for black rot (see spray schedule, p. 74). For vinifera grapes on the Pacific slope dusting with sulphur has been found to be the most economic and efficient method of controlling this disease. Very fine sulphur, either ground or sublimed, should be used. It can be most effectively applied with a hand-dusting machine such as shown in figure 77 or a similar type. A can with perforated bottom or a cloth sack is frequently used, but this method is less effective and not economical.

Three thorough applications are usually sufficient to insure satisfactory results. The first application should be made when the new shoots are 6 to 8 inches long; the second just before or during blossoming. If the first two treatments have been thorough, practically covering all the foliage, the third dusting should not be necessary except under weather conditions unusually favorable for the disease or with very susceptible varieties.

If a third treatment is necessary, it may be made when the fruit is about half grown.

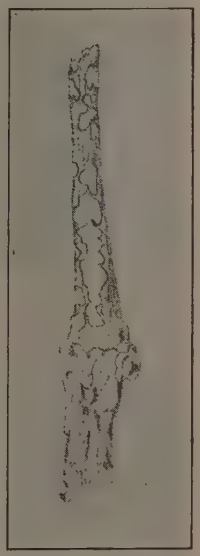


FIG. 61.—Grape shoot, showing spots produced by anthracnose.

ANTHRACNOSE.

Anthracnose[32] has also been called "bird's-eye rot," on account of the peculiar spots it produces upon affected grapes. Like most other diseases of the grape, it attacks the leaves and shoots, as well as the fruit. On the leaves it at first appears as minute, irregular, dark brown, slightly sunken spots, having a darker margin. These spots usually become lighter colored when old, and frequently crack or fall out, leaving irregular holes in the leaves. This disease presents much the same appearance on the shoots as on the leaves, though the spots are frequently larger and more sunken (fig. 61). They also tend to run together and form irregular patches or cankers.

The disease is most characteristic and conspicuous upon the fruit. The spots are usually brown at first and surrounded by a narrow, dark purplish margin; they increase in size and gradually become

[32] Caused by *Sphaceloma ampelinum* De By.

grayish white and somewhat sunken. Frequently two or more spots unite and cover a considerable part of the berry. The affected tissues do not become softened, as in the case of the downy mildew, but the fruit finally becomes hard and more or less wrinkled. If only a small part of the berry is affected, it may continue to grow, causing the diseased area to rupture and the seeds to become exposed. The bursting of the berries and the exposure of the seeds may, however, be produced by other causes, such as the powdery mildew and certain physiological disturbances or insect injuries.

On the diseased areas the minute spores or germs of the fungus are frequently produced in immense numbers. The way in which these spores are borne is shown in figure 62. The winter form of spore produced by this fungus is apparently not common. The fine, threadlike filaments which constitute the vegetative part of the parasite live during the winter in the tissues of the vines and are ready for active growth in the spring.

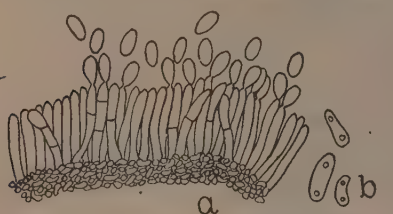


FIG. 62.—Section of an anthracnose spot, highly magnified: *a*, Showing the way in which the spores are borne; *b*, three of these spores more highly magnified.

The anthracnose is quite widely distributed in this country, but fortunately has not caused any great general loss. It is rather erratic in its behavior, sometimes being very serious in one locality or on a particular variety, but not general. It may attack vinifera grapes seriously where climatic conditions are favorable, as in the southern part of Texas and on the Gulf coast. On the Pacific coast the disease is not known to occur. It should be carefully watched, however, as when once well established under favorable conditions its control is difficult.

TREATMENT.

All branches or shoots showing cankers should be cut out and burned during the winter. Spray the vines thoroughly with commercial lime sulphur, 1 gallon of lime sulphur to 9 gallons of water, just before growth starts in the spring. During the growing season spray with Bordeaux mixture as indicated in the spray schedule (p. 74). Lime-sulphur solution has been found just as effective as sulphuric acid for a dormant application and much less unpleasant and dangerous to handle. A comparison of figures 63 and 64 will show the benefits resulting from this method of treatment.

RIPE-ROT.

Ripe-rot[33] has also been called bitter-rot. The name bitter-rot is, however, applied to another fungous disease of the grape (p. 62). As

[33] Caused by *Glomerella cingulata* (Atk.) Spauld. & v. Schrenk.

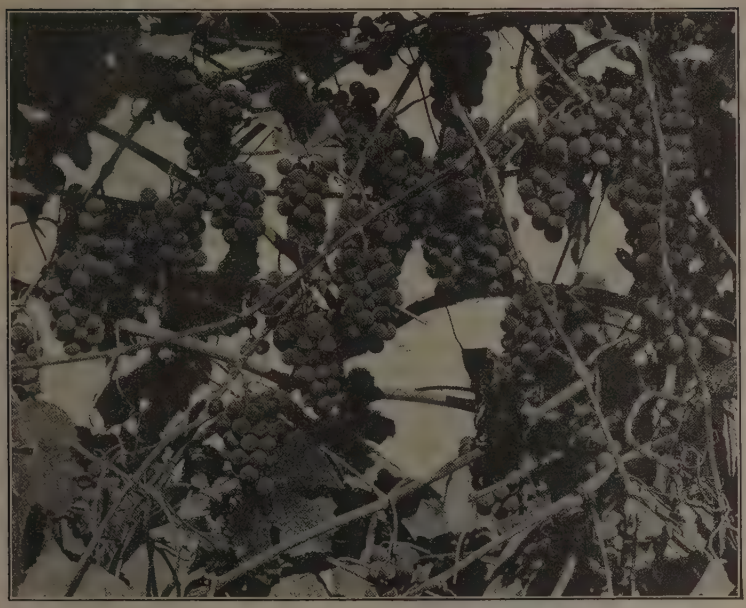


FIG. 63.—A portion of an average vine with some leaves removed, showing the condition of fruit on the treated portion of the vineyard in 1912.

FIG. 64.—A portion of a vine from the control plat in 1912 seriously damaged by anthracnose, about the same number of bunches being shown as in figure 63.

the present name indicates, the disease usually appears on the fruit when the latter is nearly mature, and under favorable conditions continues its development and destruction of the fruit after the grapes are picked. It also attacks the leaves and stems, but is most noticeable and injurious on the fruit. The first indication of the disease is the appearance of reddish-brown discolored spots (fig 65), which spread and finally extend over the whole fruit. The surface then becomes dotted with dark, slightly elevated pustules, in which the spores are borne. At this stage of development the disease is not easily distinguished from the early stages of black-rot and bitter-rot. The berries do not shrivel up, however, as in the case of the black-rot, and usually are easily detached from the bunch. The spores mentioned are produced in large numbers and serve to spread the disease.

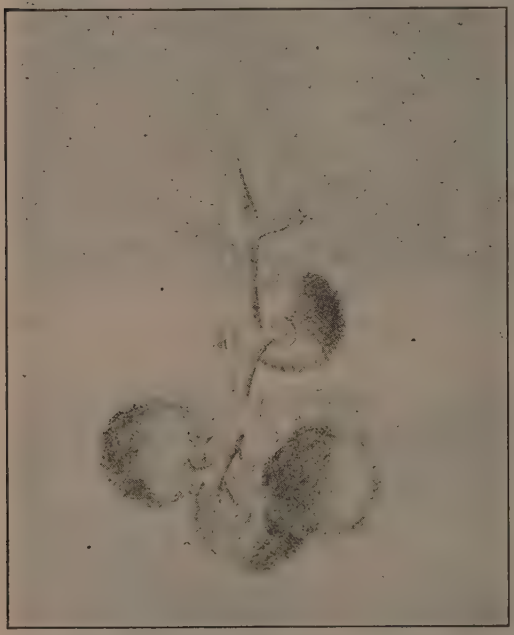


FIG. 65.—Grapes attacked by the ripe-rot fungus.

The fungus causing this disease is closely related to that which produces the bitter-rot of the apple, and by some is regarded as the same; but no entirely conclusive cross-inoculation experiments have yet been reported. The pathologists of the Department of Agriculture have demonstrated by means of pure cultures of this fungus that there is another stage, producing spores very similar in appearance to those just mentioned, but borne in sacs which are inclosed in spore cases similar to those of the black-rot fungus. This spore form is of very infrequent or doubtful occurrence in vineyards, and is probably not an important factor in the distribution of the disease.

It is difficult to determine how much injury is done by this disease on account of the likelihood of confusing it with other fungous troubles and its usual occurrence with other diseases. It is quite generally distributed, and may cause more loss than is usually attributed to it.

TREATMENT.

Spray as recommended for black-rot in the spray schedule (p. 74). The later applications are especially important and should be very thorough.

DEAD-ARM.

Dead-arm of grapevines is caused by a wound parasite.[34] The organism, having gained entrance to the trunk or branches of the vine, continues to grow and kill the tissues, forming a dead spot or canker, as shown in figure 66, and finally encircles the whole cane, causing the part of the vine beyond to die. Figure 67 shows a vine in which the fungus has attacked the trunk just above the two lower arms, causing the death of the whole upper portion of the plant. Cankers on dead areas, caused by the fungus, become more or less covered with the small black pustules or fruiting bodies which produce the spores of the fungus.

Magnified views of these fruiting bodies and also of the various spore forms which they produce are shown in the accompanying illustration (fig. 68). This fungus has three spore forms, two sometimes called summer spores and one winter spore form. Most of the new cases of the disease are apparently occasioned by the summer spores which are very abundant. The winter spore form is apparently rare in occurrence.

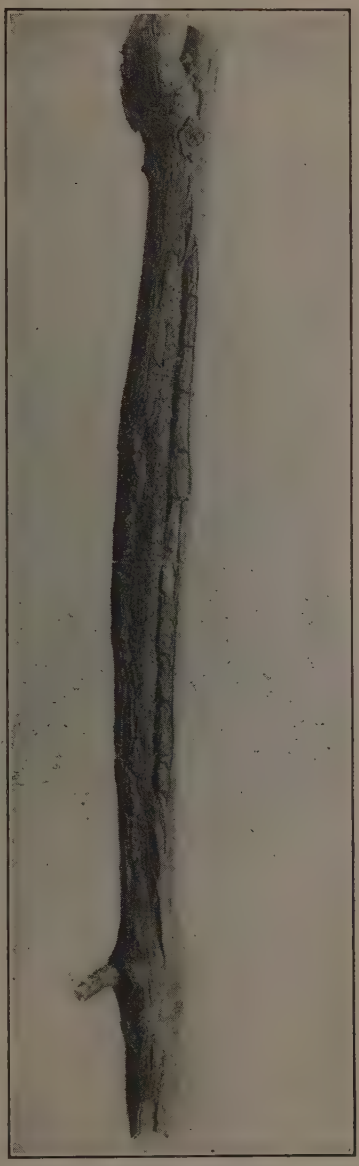


FIG. 66.—Dead-arm canker on a young vine. The minute black pustules on the dead portion of the canker are fruiting bodies of the fungus.

[34] *Cryptosporella viticola* (Red.) Shear.

This disease is rather common in the vineyards of New York, Pennsylvania, Ohio, and Michigan.

TREATMENT.

Spraying does not prevent this disease. As soon as the first conspicuous symptom of the disease is noticed, which is the development of weak, slender shoots, with small yellowish leaves, as shown in figure 69, an examination should be made of the vine between the

FIG. 67.—Dead-arm disease of grape. The portion of the vine above the lower wire has been killed by the dead-arm fungus. The point of infection is just above the lower trellis wire. The parasite has girdled the vine at this point, causing the death of the portion above.

point of origin of this weak shoot and the next healthy shoot below, in order to locate the diseased spot or canker. Having located the canker, the vine should be cut off far enough below this to be sure of removing all of the infected wood. These prunings should be burned at once.

If the canker forms on the main trunk below the arms, the vine should be cut off near the ground. The root will then send up vigorous, healthy shoots. The disease apparently does not attack the roots.

CROWN GALL OF GRAPE.

Crown gall is a disease caused by a bacterium.[35] This germ is a wound parasite which, after gaining entrance to the root or cane of the vine, causes an abnormal gall, wart, or elongate tumorlike outgrowth, sometimes of considerable size, as shown in figure 70,

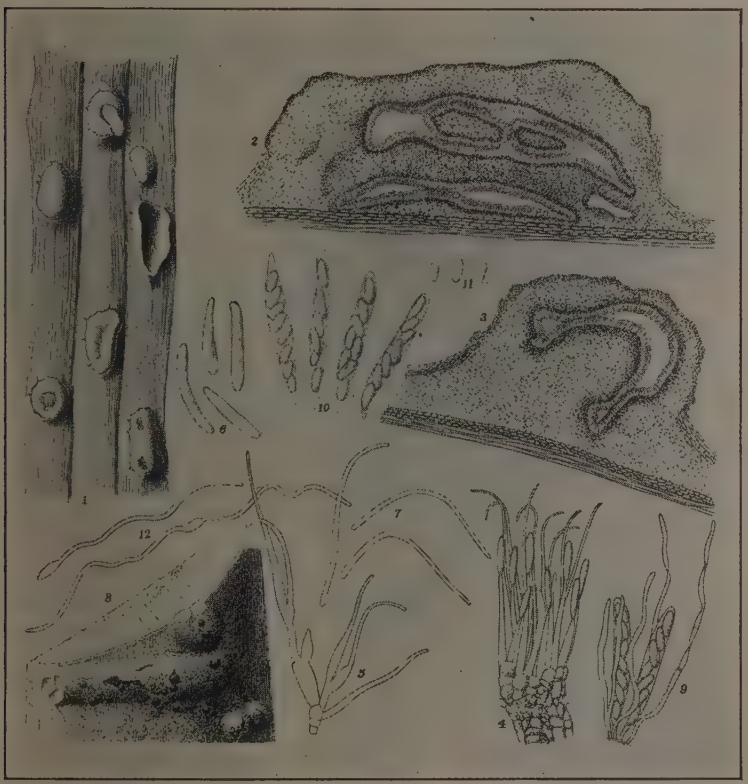


FIG. 68.—The dead-arm fungus. (1) Fruit bodies (pycnidia); (2) Section through one of these fruiting bodies. (3) Another section of smaller fruiting body. (4) Summer spores or pycnospores. (5) Sporophores. (6) and (7) Two forms of spores produced in the pycnidia. (8) Portion of dead cane showing perithecia. (9), (10), and (11) asci and spores from (8). All but (1) and (8) highly magnified.

at other times of smaller size and very numerous, extending along the trunk or branches of the vine.

The larger galls shown in figure 71 are most frequent on the European varieties of grapes which are grown on the Pacific coast and in the Southwest. The smaller and more numerous galls united in elongate masses are the common form on American varieties of

[35] *Bacterium tumefaciens* Smith & Townsend.

grapes in the East. This disease is not common on American varieties and does not usually cause serious loss. It has been most frequently found in heavy or wet, poorly drained spots in vineyards, and may in some cases follow winter injury of the vine.

TREATMENT.

As the germ producing the disease lives in the soil, it can not be controlled by spraying. Diseased plants showing galls at the crown should be dug up and destroyed by burning. Where galls are confined to branches these should be removed far enough below the gall

FIG. 69.—Dead arm of grape. The right arm is nearly killed by the disease. The canker produced by the fungus is located between the terminal, abnormal, weak shoot and the fully developed healthy shoot near the base.

to include all affected tissues. In setting new plants great care should be taken to see that they are entirely free from any signs of swellings or galls on the roots or canes. As this disease also attacks various fruit trees and bushes and other cultivated plants, soil in which such diseased plants have been found should be avoided, if practicable, in planting grapevines.

LESS IMPORTANT DISEASES.

BITTER-ROT

Fruit attacked by bitter-rot [36] presents an appearance very similar to that produced by the ripe-rot. Bitter-rot is no doubt sometimes

[36] Caused by *Melanconium fuligineum* (Scrib. & Viala) Cav.

confused with other diseases, such as ripe-rot and black-rot. It is most frequently found in the Southern States and is not usually serious enough to need special treatment.

Treatment.—Spraying as directed for black-rot will probably prevent this disease.

WHITE-ROT.

The effect of the disease known as white-rot[37] upon the fruit of the grape is somewhat similar to that of the brown-rot form of the downy mildew. It is frequently confused with ripe-rot. It occurs in Missouri and the Southwest, but has not yet been found sufficiently destructive to need special treatment.

ROOT-ROTS.

The roots of the grape are known to be attacked by several different fungi, especially when the root system has become weakened or injured by other causes. Only two forms of root-rot are of sufficient importance to be mentioned here.

VIBRISSEA ROT.

The vibrissea rot[38] is usually associated with insect injury, due either to Phylloxera or to the grape root-worm. It has been found

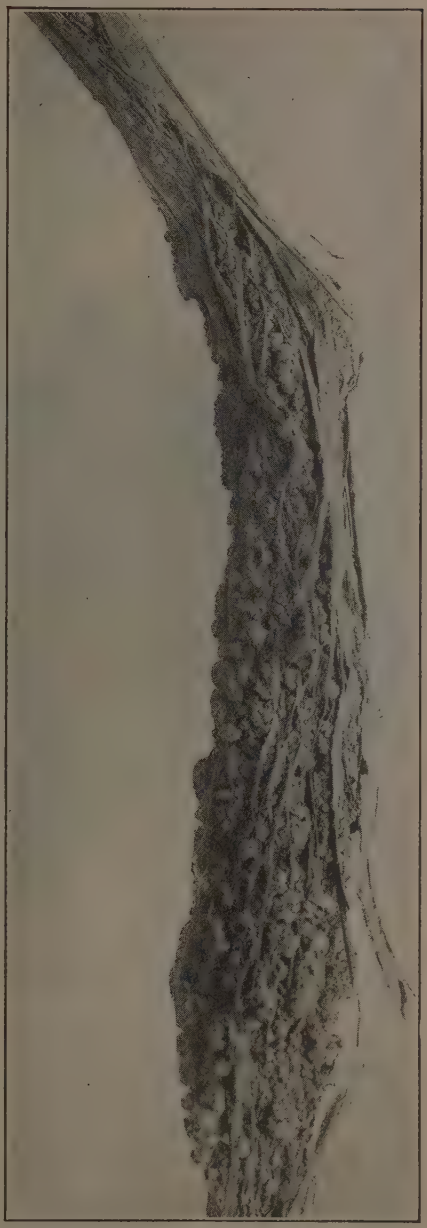


FIG. 70.—Crown gall on Concord grapes. The numerous wart-like galls are mostly produced on the main stem and larger branches in Eastern vineyards.

[37] Caused by *Coniothyrium diplodiella* (Speg.) Sacc.

[38] Caused by *Vibrissea hypogaea* Ch. Richon & Le Monnier.

in New York, Pennsylvania, and Missouri, and where present appears to hasten the death of plants, especially those injured by the rootworm.

Treatment.—This fungous rot can be prevented only by the destruction of the insects which injure the root system and thus give the fungus opportunity to gain a foothold. (See control of grape rootworm, pp. 42–43.)

OZONIUM ROT.

There is a root-rot of a more serious nature, ozonium rot, prevalent in and chiefly restricted to Texas, New Mexico, and Arizona. This is attributed to a fungus[39] which also attacks the roots of cotton and a great variety of other plants. It is most destructive in the black waxy, clay soils, which are very poorly aerated. Plants attacked die suddenly, the leaves and fruit withering up in a day or two and remaining on the vines.

FIG. 71.—Crown gall on a vinifera grape. The large galls have formed near the crown of the plant just at the surface of the soil.

Treatment.—No remedy is known for this root-rot of the grape. Soil upon which other plants have died with the same disease should be carefully avoided in planting vines, and poorly drained, heavy soils should also be avoided if possible.

SHELLING.

The shelling or dropping of grapes from the bunches before maturity may be due to various causes. In certain localities in New York and Pennsylvania this trouble is rather serious some seasons. The cases which the department has had an opportunity to study have been found to be associated mostly with the dead-arm disease in its early stages. Unfavorable climatic conditions as well as unbalanced nutritive conditions also apparently tend to produce this trouble.

[39] *Ozonium omnivorum* Shear.

INSECTICIDES.

ARSENATE OF LEAD.

Arsenate of lead is the arsenical principally used in spraying grapes, and the commercial article is probably universally employed. It comes on the market in both powdered and paste forms, though the former is now rapidly replacing the latter. Arsenate of lead is used for the control of biting or chewing insects, such as the grape-berry moth, the grape rootworm, the rose-chafer, various caterpillars, and the like. It can be added to Bordeaux mixture, used for the control of fungous diseases, without reducing its effectiveness, or used alone in water, in which case there should be added to the spray the milk of lime from slaking 2 or 3 pounds of good stone lime for each 50 gallons to obviate danger of burning the foliage.

The powdered arsenate of lead is used on grapes mostly at the rate of 1½ pounds, and the paste form at the rate of 3 pounds per 50 gallons of spray. Before adding the powdered arsenate of lead to the spray tank it should be mixed with a little water. Water should also be added to the paste and the whole worked until of a thin consistency.

NICOTINE SOLUTION.

Nicotine or tobacco extract is used principally for the control of the grape leafhopper and plant-lice. It may be extracted from tobacco refuse by soaking in the full quantity of water, with occasional stirring, for a period of about 24 hours. This removes about 70 or 80 per cent of the nicotine; and after straining to remove coarse particles the solution is ready for use. The nicotine content of tobacco refuse, stems, etc., varies widely, and the number of pounds to use with a given quantity of water to obtain an effective extract can not be accurately indicated without chemical analysis. In general, however, a pound of the refuse for each gallon of water will yield sufficient nicotine for a killing spray. Those especially interested in the utilization of refuse tobacco for spraying purposes should consult Farmers' Bulletin 908, United States Department of Agriculture.

Nicotine is offered for sale in various grades, and a concentrated preparation is the so-called 40 per cent nicotine sulphate, containing 40 per cent of nicotine. The nicotine strength of the commercial articles will not affect their insecticidal value if diluted so that the spray will contain about 0.05 per cent of nicotine. In spraying with homemade tobacco extract or with commercial nicotine solution in water a soap should be added, preferably rosin fish-oil soap, at the rate of 1 pound to 50 gallons of spray. If this soap is not available, 2 pounds of ordinary laundry soap may be used.

ROSIN FISH-OIL SOAP.

Abundant experience has shown that a small amount of soap added to sprays increases their spreading and adhesive qualities. Of the various soaps available the rosin fish-oil soap has proved best and has come into considerable use in sprays for grapes, plums, cranberries, etc. The soap is used at the rate of 1 pound to 50 gallons of spray and may be added to a spray composed of Bordeaux mixture, arsenate of lead, and nicotine sulphate, or used with any one of these, in water.

In the absence of fish-oil soap, ordinary laundry soap may be used at about twice the strength of the fish-oil soap, namely, 2 pounds to 50 gallons of spray.

Soap sprays may also be used for the destruction of various soft-bodied insects, as plant-lice, the leafhopper, etc. For plants in foliage the soap, according to its quality and the insects to be treated, is used at the rate of 1 pound to 3 or 4 gallons of water, or at even greater dilutions. If a fish-oil soap be employed for the treatment of vines during the dormant condition, it should be used at the rate of 2 pounds for each gallon of water, as for the grape scale.

SELF-BOILED LIME-SULPHUR MIXTURE.

The self-boiled lime-sulphur mixture, while primarily a fungicide for the treatment of stone fruits, has come into some use as an insecticide. According to experiments by the New Jersey Agricultural Experiment Station it is effective in preventing injury to grapes by the rose-chafer (pp. 20–23).

Except under special conditions, sulphur sprays should not be used for spraying grapes.

The self-boiled lime-sulphur mixture may be made as follows:

Stone lime	pounds	8, or 2
Sulphur (commercial ground[40] or flowers)	do	8, or 2
Water to make	gallons	50, or 12½

The lime should be placed in a barrel or suitable container and enough water poured on almost to cover it. As soon as the lime begins to slake the sulphur should be added, after first running it through a sieve to break up the lumps. The mixture should be stirred constantly and more water added as needed to form a thick paste at first and then gradually a thin paste. The lime will supply enough heat to boil the mixture several minutes. As soon as it is well slaked cold water should be added to cool the mixture and prevent further cooking. It is then ready to be strained into the spray tank, diluted, and applied.

[40] Commercial ground sulphur is the cheaper and is equally as satisfactory as the flowers of sulphur.

The stage at which cold water should be poured on to stop the cooking varies with different grades of lime. Some limes are so sluggish in slaking that it is difficult to obtain enough heat from them to cook the mixture at all, while other limes become intensely hot on slaking, and care must be taken not to allow the boiling to proceed too far. If the mixture is allowed to remain hot 15 or 20 minutes after the slaking is completed the sulphur gradually goes into solution, combining with the lime to form sulphids, which are injurious to peach foliage. It is therefore very important, especially with hot lime, to cool the mixture quickly by adding a few buckets of water as soon as the lumps of lime have slaked down. The intense heat, violent boiling, and constant stirring result in a uniform mixture of finely divided sulphur and lime, with only a very small percentage of the sulphur in solution. It should be strained to take out the coarse particles of lime, but the sulphur should be carefully worked through a strainer. The mixture can be prepared in larger quantities if desired, say, enough for 200 gallons at a time, making the formula 32 pounds of lime and 32 pounds of sulphur to be slaked with a small quantity of water (8 or 10 gallons) and then diluted to 200 gallons. Arsenate of lead and nicotine solution may be added to this mixture, exactly as with Bordeaux mixture. Soaps should not be used in lime-sulphur sprays.

KEROSENE EMULSION.

Kerosene emulsion has long served as a standard spray for the control of soft-bodied sucking insects, especially aphids or plant-lice. If well made and properly diluted it will give satisfactory results for this purpose. *It should never be combined with lime sulphur.*

A good stock solution of kerosene emulsion containing 66 per cent of oil may be made according to the following formula:

Kerosene (coal oil, lamp oil)	gallons	2
Fish-oil or laundry soap (or 1 quart soft soap)	pound	½
Water	gallon	1

First dissolve the soap in boiling water, then remove the vessel from the fire. Immediately add the kerosene and thoroughly agitate the mixture until a creamy solution results. The stock solution may be more conveniently made by pouring the mixture into the tank of a spray pump and pumping the liquid through the nozzle back into the tank for some minutes. The stock solution, if properly made, should last for some time, but it is better to make it up as needed. Do not dilute until ready to use. To make a 10 per cent spray (the strength for trees in foliage) add for each gallon of the stock solution about 5⅔ gallons of water. For 20 and 25 per cent emulsions (for use on dormant vines) use, respectively, about 2⅓ and 1⅔ gallons

of water for each gallon of stock solution. Agitate the mixture in all cases after adding the water.

The preparation of the emulsion may be simplified by the use of a naphtha soap. No heat will be required, as the kerosene will combine readily with the naphtha soap in water when thoroughly agitated. If naphtha soap is used, twice as much will be required as is given for the other kinds of soap in the foregoing formula, and soft or rain water should be used in making the emulsion. In regions where the water is "hard" this should first be "broken" with a little caustic potash or soda, or common lye, before use for solution, to prevent the soap from combining with the lime or magnesia present, thus liberating some of the kerosene; or rain water may be employed.

FUNGICIDES.

BORDEAUX MIXTURE.

The form of Bordeaux mixture which has been found most effective in the control of grape diseases is composed of 4 pounds of bluestone (copper sulphate) and 3 pounds of stone lime to 50 gallons of water. To prepare Bordeaux mixture for use in an ordinary barrel sprayer, dissolve 4 pounds of bluestone in 25 gallons of water and in a separate container slake 3 pounds of stone lime and dilute to 25 gallons; then pour these solutions simultaneously through a strainer into the spray barrel and stir thoroughly. When a considerable number of vines are to be sprayed it will be most convenient and economical to prepare the bluestone and lime in the form of stock solutions by dissolving in a barrel a quantity of bluestone at the rate of 1 pound to 1 gallon of water. The bluestone should be suspended in a sack in the upper part of the barrel or other wooden container so that it is just beneath the surface of the water. It will dissolve if left overnight in cold water and more quickly if hot water is used. Stock solutions of lime are made by slaking the desired quantity of lime in a small quantity of water and then diluting so that 1 gallon of water contains 1 pound of the lime.

Before using the stock solutions, especially the lime, they should be thoroughly stirred. To prepare 50 gallons of Bordeaux mixture from the stock solutions, take 4 gallons of stock solution of bluestone and 3 gallons of stock solution of lime. If any other form of lime than good stone lime is used it will probably be necessary to use 4 pounds to 50 gallons, especially when arsenate of lead is also used. Dilute them in separate containers and pour them together into the spray tank. Unless the solutions are diluted at the time they are poured into the spray tank, it is necessary to agitate the mixture thoroughly as the materials are being poured in. A very satisfactory Bordeaux mixture can be made by pouring the stock solution of blue-

stone into the sprayer tank which has been filled three-fourths full of water, then pouring the lime stock solution through the strainer, adding enough water to fill the tank and keeping the agitator working. The important thing in making good Bordeaux mixture is to stir or agitate the materials sufficiently as they are mixed to afford an opportunity for the proper combination of the lime and bluestone.

BORDEAUX MIXING PLANTS.

When using Bordeaux mixture in large quantities much time may be saved if arrangements are made for convenient handling of the

FIG. 72.—Bordeaux mixing plant.

stock solutions and the water needed. Figure 72 shows an arrangement for rapid preparation of Bordeaux mixture. Various modifications of this plan can easily be devised to suit the conditions and requirements in any particular case. The main feature is to have the lime, bluestone, and water arranged on platforms or in tanks high enough so that the solutions may be handled by gravitation. The water supply tank should be on the upper platform and connected by pipes to dilution barrels, which may be connected by 3 or 4 inch pipes with a flexible hose through which the Bordeaux mixture may be

conducted into the spray tank below. By the side of each of these dilution tanks a 50-gallon barrel, one containing stock solution of bluestone and the other stock milk of lime, should be placed. Each gallon of stock solution should contain 1 pound of bluestone or 1 pound of lime.

To make 200 gallons of Bordeaux mixture, 4–3–50 formula, with a mixing plant of this type, dip out 12 gallons of well-stirred stock milk of lime and pour into the lime dilution barrel or tank and pour 16 gallons of stock bluestone solution into the bluestone tank. Then fill each of these tanks to the 100-gallon mark by running in water from the storage tank above or whatever the most convenient source of water supply may be. The stopcocks of the dilution tanks may be opened then so that the diluted lime and bluestone may run together through the discharge pipe and into the spray tank, the opening of which should be covered by a good brass wire strainer in order to remove any sediment or dirt present and avoid clogging of the spray nozzles. If more convenient, water may be pumped directly into the sprayer tank until it is three-fourths full. Then add the stock solution of bluestone, after which the stock lime may be added, diluting as necessary to make it pass through the strainer and fill the sprayer tank. While the lime is being added the agitator should be kept running in order to insure thorough mixing of the ingredients. If thoroughly agitated, a Bordeaux mixture made in this way is entirely satisfactory.

FIG. 73.—Bucket spray pump.

NEUTRAL COPPER ACETATE.

Neutral copper acetate, or basic copper acetate, dissolved at the rate of 1 pound to 50 gallons of water, has been found to be the best nonstaining preparation for use on grapes when nearly mature.

SPRAYERS.

BUCKET PUMPS.

Bucket pumps (fig. 73) are convenient for spraying small gardens and shrubs or a few small trees. They should be made of brass or other noncorrosive metal and preferably equipped with an agitator. In some of these pumps agitation is provided by means of a small jet of liquid that is forced from the bottom of the pump through

the mixture as the pump is operated. For convenience in use these pumps may be clamped to the bucket or used free in a tub or other vessel containing the spray material. They should be supplied with a spray rod and sufficient hose to reach conveniently all parts of the plants to be sprayed.

SMALL COMPRESSED-AIR PUMPS.

Compressed-air pumps (fig. 74) are frequently used in small fruit gardens and are preferred to the bucket pump by those who do not wish to pump while applying the spray. These pumps are usually made of brass or galvanized sheet steel and have a capacity of 3 to 4

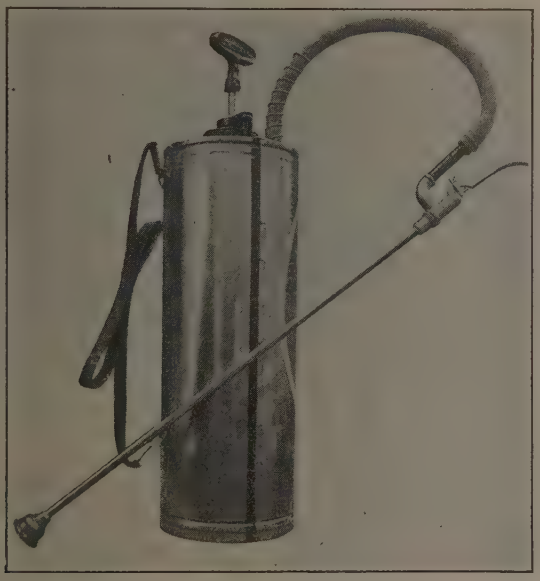


FIG. 74.—Compressed-air sprayer.

gallons. They are carried by means of a shoulder strap. In the better types agitation is provided by the entrance of the air at the bottom of the tank. After the spray material is poured into the tank and the opening closed by an air-tight cap, the air is pumped until the liquid is under sufficient pressure. The tank is usually emptied by three or four pumpings of a dozen strokes each.

BARREL PUMPS.

The barrel hand-pump outfit (fig. 75) has a capacity of about 50 gallons and is widely used for the fruit or the home orchard, small vineyard, and fruit garden. The pump should be provided with an efficient agitator, either of the paddle or rotary type. To insure

sufficient pressure and uniform discharge of the spray material, the pump should be provided with an adequate air chamber to which a pressure gauge may be attached if desired. The pump may be mounted either on the head or side, and the whole outfit placed on a cart or sled or wagon.

SPRAYING OUTFITS FOR LARGE OPERATIONS.

Spraying outfits for large vineyards are generally operated by gasoline engines, although traction sprayers and compressed-air outfits are sometimes used.

GASOLINE POWER SPRAYERS.

Spraying outfits operated by gasoline engines are by far the most useful type of sprayer and are made in various sizes and styles to suit almost any requirement. Special outfits have been designed for vineyard spraying. Some have a series of fixed nozzles attached at either side at the rear. These may give satisfaction for spraying when the vines are young and all parts can be easily covered. After the fruit is set, however, it is necessary to use an outfit operated with trailers, that is, long leads of hose having the nozzles directed by hand, as shown in figure 76. With a small power outfit a one-leader hose is generally used. Two leads may be employed with a pump of sufficient capacity to keep up the necessary pressure. Large power sprayers are made with pumps of from two to four cylinders, having a capacity of 5 to 15 or more gallons per minute under a pressure of 150 to 300 pounds. These sprayers are equipped with engines of from 2 to 4 horsepower.

FIG. 75.—Barrel-spray pump.

The various spraying outfits now on the market differ much in durability and efficiency. The fruit grower, therefore, before selecting an outfit should study carefully the various kinds and determine by observation and inquiry from users which outfit will best meet his requirements.

DUSTING APPARATUS.

Apparatus of various styles adapted to a wide range of use for applying insecticidal and fungicidal dusts is available on the market.

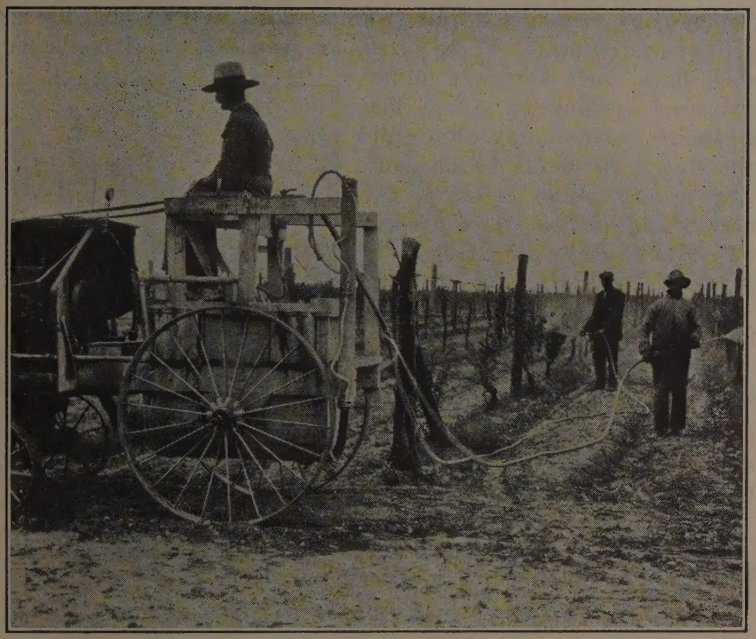


FIG 76.—Gasoline power grape sprayer, illustrating the so-called trailer method of applying the spray.

For use in a small vineyard a small hand-duster similar to that shown in figure 77 would be sufficient. Power dusters of various sizes are also available for larger operations.

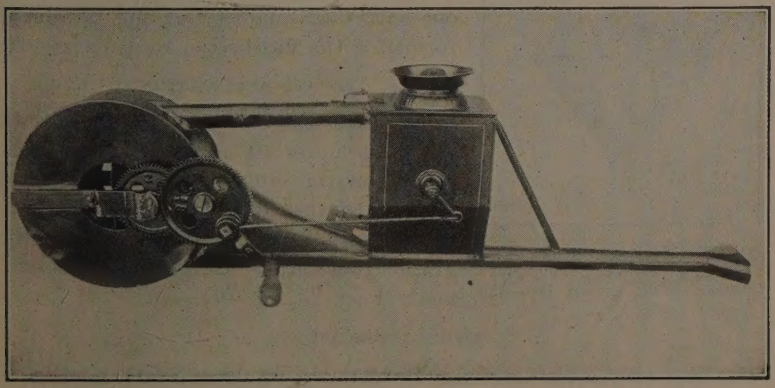


FIG. 77.—Hand duster for applying dust mixtures in the fruit garden.

SPRAYING ACCESSORIES.

SPRAY NOZZLES.

The disk-whirlpool type (fig. 78) of spray nozzle is extensively employed by commercial fruit growers and is well adapted for use with vineyard outfits. These nozzles are provided with interchangeable disks, each having a different sized opening to give a fine, medium, or coarse spray. For rapid spraying with outfits having sufficient capacity and pressure, two nozzles may be used on each spray rod. These may be attached by means of a Y.

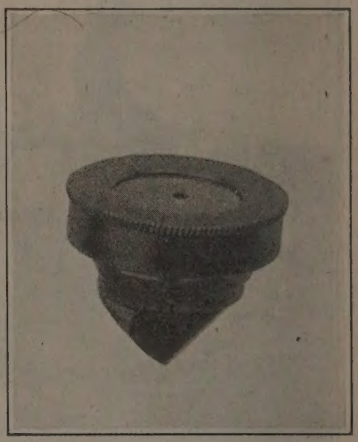


FIG. 78.—Angled nozzle of the eddy-chamber of whirlpool-disk type.

STRAINERS.

To avoid trouble and delay from clogging of nozzles it is necessary thoroughly to strain the mixture as it is put in the sprayer. A strainer such as is shown in figure 79 is convenient for this purpose. The brass-wire screen should be 20–22 mesh to the inch.

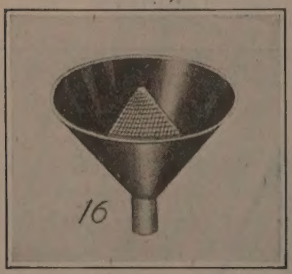


FIG. 79.—Strainer for use in removing sediment in sprays when being poured into the spray tank.

GRAPE-SPRAYING SCHEDULE.

FIRST APPLICATION.

About a week before the blossoms open, or when the new shoots are from 12 to 18 inches long, spray with Bordeaux mixture 4–3–50 (pp. 68–70) for fungous diseases, adding 2 to 3 pounds of arsenate of lead paste, or one-half that quantity of the powdered form, for the flea-beetle, rose-chafer, etc.

SECOND APPLICATION.

Just after the blossoms fall spray with the same materials as in the first application for the same fungous disease and insects and also for the grape-berry moth, grape leafhopper, and the adults of the grape rootworm, using the "trailer" method (p. 73, fig. 76).

THIRD APPLICATION.

About two weeks later use Bordeaux mixture 4–3–50, arsenate of lead paste 2 to 3 pounds (or one-half quantity of powdered arsenate

of lead), 40 per cent nicotine sulphate ¼ pint, and 1 pound rosin fish-oil soap to 50 gallons of spray mixture for fungous diseases, the berry moth, eight-spotted forester, grape leaf-folder, grapevine aphis, grape rootworm, and grape leafhopper. To destroy the leafhopper direct the spray against the lower surface of the leaves. To control the berry moth thoroughly coat the grape bunches with the spray, directing the spray nozzle by hand.

FOURTH APPLICATION.

About 10 days later, or when the fruit is nearly grown, if black-rot, mildew, or ripe-rot are still appearing, spray with 4–3–50 Bordeaux mixture, or if there is danger of the Bordeaux mixture adhering to the fruit when picked use neutral copper acetate or verdigris at the rate of 1 pound to 50 gallons of water, adding 1 pound of commercial rosin fish-oil soap. In severe cases of black-rot and ripe-rot a fifth application may be necessary, in which case the period between the earlier applications should be somewhat shortened and neutral copper acetate solution used. To secure satisfactory results the spraying must be timely and thorough so as to cover as nearly as possible the entire surface of the foliage and fruit with a fine spray.

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1921